Electrochemical and Metallurgical Industry

Vol. III. NEW YORK, NOVEMBER, 1905. No. 11.

Electrochemical and Metallurgical Industry

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

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Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Entered as Second-Class Matter, June, 1903, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

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CONTENTS.

Copper Smelting as a Process for Recovering Gold aud Silver.

In the past ten years copper smelting has gained on lead smelting and the chlorination process, as a method the "rationale" of which is the recovery of the precious metals. Of course, there have been advance steps in these competing branches, but copper smelting has made the greater progress. Furnace treatment to a 50 per cent matte in the large shaft furnace and, what is having a wave of metallurgical popularity, the large reverberatory matting furnace are both very cheap concentrating processes and both entail very small losses, for copper slags often average as low as 0.36 per cent Cu. Blowing this matte to blister copper is a very cheap process, for copper Bessemerizing resembles the iron Bessemer process in putting an enormous tonnage through a small plant with a small number of laborers, and the copper process has the added advantage of the possible use of a silicious gold ore as a lining whose values are all "velvet" to the process. But the greater advantage of the copper complex treatment is found in the last stage —the electrolytic refining. Here the copper is turned out chemically pure and 98 to 99 per cent of actual values—not simply assay values, for these are usually exceeded—of gold and silver are recovered. Often nickel and cobalt are recovered and many other by-products are possible.

* * *

In competition with lead smelting as a means for collecting the precious metal, the copper process, we see, has superiority over the lead process which uses the zinc-desilverizing method —cheap and practical to be sure, but not as finished or neat as electrolytic copper refining. In the field of ore treatment, the copper furnace is cheaper in construction and uses less coke, especially if the furnace be operated so as to employ the available heat of the sulphur and iron of the pyrites. While the lead furnace must be very carefully operated, using a low temperature to prevent volatilization of lead and a very fusible slag which restricts ore purchases to certain classes of ores, the copper furnace has no such delicate apetite but takes in its voracious maw slags of a wide range of composition. Its losses are much lower for the reason that high temperature of the smelting zone keeps the slags liquid and allows perfect separation. The question of proper reduction of iron oxide and the elimination of the iron as iron matte is, of course, a problem in each furnace, but a much less difficult one with the copper furnace. The question of elimination of zinc (for all lead plants run their slags to 6 to 8 per cent ZnO, and use as much zinc ores carrying high lead gold and zinc values as possible) is less serious in the copper furnace with its short shaft than in the long shaft of the lead furnace. Here incrustations are naturally much more liable to occur. In fact, at Carson City, Col., a copper matting furnace on high zinc

charge operates successfully with 18 inches between tuyeres and charging floor—a real dwarf of a furnace!

* * *

If reverberatory smelting is employed, the question of slags and degree of reduction do not enter the proposition at all, for by independent firing with soft coal any heat up to 1600° C. can be reached. The plant is not dependent on coke, but can use a poor quality of soft coal or wood in remote districts. In fact, the Argo plant of the Boston & Colorado Co., near Denver, has competed for years with the Colorado lead smelters for gold and silver ores. This plant has always used a refining process for gold and silver that is many dollars less favorable than electrolytic copper refining. Such are the inherent virtues of copper smelting when considered as a means for treating gold ores that it succeeds in poor conditions. With the great increase in consumption of copper, due to general expansion in the electrical business, the capacities of the electrolytic copper refineries near New York have gone up with leaps and bounds, and are about double what they were only six years ago. The American Smelting & Refining Co. and the De Lamar Co. are both enlarging their refineries to a capacity of 60,000 tons of copper each per year; the Raritan Copper Works within a year will be producing 24,000,000 pounds of copper monthly. The Balbach Smelting & Refining Co. is enlarging its plant, while the Nichols Chemical Co.'s monster plant is operating at almost full capacity, producing some 17,000,000 pounds per month. Considered in its entirety, the future of copper smelting, both for its main products and for the by-products, gold and silver, is most bright, and in all probability this rate of growth will increase. Its cause can be traced to metallurgical and commercial conditions for expansion.

Partial Pressure, Partial Volume and the Lungwitz Zinc Process.

When certain quantities of different gases at the same pressure and the same temperature are brought together and allowed to intermingle, then—if there is no chemical reaction but simply diffusion—we know from experience that the volume of the gas mixture will be equal to the sum of the volumes of the constituent gases if the pressure and temperature are maintained at their original values. Diffusion will, of course, take some time, but finally a state of equilibrium will be reached in which the gas mixture is of homogeneous composition throughout the volume. *A priori* it would be possible to form two different and equally probable conceptions concerning this homogeneous composition. The first conception is to assume that each of the constituent gases maintains its individuality, that it simply disintegrates (mechanically) into a very large number of minute particles, each particle having the same volume and pressure as before. The gas mixture then is an agglomeration of minute particles of the different constituent gases side by side. In each particle there is the same pressure as before. The pressure is common to all constituent gases. But the total volume is not common to all; each infinitely small space is filled with one and only one gas; the total volume is the sum of the "partial volumes" of the different constituent gases, each "partial volume" being equal to the original volume which that gas had before diffusion. The second conception is that the different gases penetrate each other during diffusion, and that each gas finally fills the total volume. Since the volume of each gas has been increased, the pressure to be attributed to it must be smaller according to the Boyle-Mariotte law. Thus we have to attribute a "partial" pressure to each gas, and the total pressure of the gas mixture is equal to the sum of the partial pressures of the different gases (Dalton's law). Hence, according to the first conception, the pressure is common to all constituent gases, but the partial volumes are different, and the total volume is the sum of the partial volumes; according to the second conception the volume is common to all constituent gases, but the partial pressures are different and the total pressure is the sum of the partial pressure.

* * *

For many purposes of calculation the one conception will be just as good as the other, and whether to prefer the one or the other will depend on the conditions of the special case—just as in electrical engineering one will calculate with resistances if the different parts of the system are in series, or with conductances if they are in parallel. But with partial pressures and partial volumes the situation is somewhat different. The two conceptions are not perfectly equivalent. By putting the question before Nature in the right way we can get a decision as to which conception is the correct one. As Planck points out in his classical lectures on thermodynamics, a distinct answer to our question may be obtained from the consideration of a vapor differing widely from an ideal gas. Take, for instance, atmospheric air and water vapor at 0° C. under atmospheric pressure. Here the water vapor cannot be supposed to be subject to a pressure of one atmosphere, since at 0° C. no water vapor exists at this pressure. The only choice remaining is to assign to the air and water vapor a common volume—that of the mixture—and different pressures—partial pressures. Then the water vapor is under much less than atmospheric pressure, and this explains its existence in vapor form.

* * *

This question is of importance for the Lungwitz zinc process which has recently received, or is receiving, a trial on a large scale at the plant of the Warren Separating Co., Warren, N. H. The peculiarity of zinc metallurgy is, of course, due to the fact that the reduction temperature of zinc oxide is above the melting point of metallic zinc at atmospheric pressure. Dr. Lungwitz' process is based on the general consideration that sufficient pressure will prevent ebullition of any liquid, even if its temperature be raised considerably beyond its boiling point under ordinary pressure. He, therefore, proposes to treat zinc oxide in a blast furnace under pressure. Dr. R. C. Schuepphaus has made some experiments in this direction, and was successful in obtaining ingots of zinc, as described in a paper before the Society of Chemical Industry in 1899, but his experiments were made in a closed electric furnace in which a comparatively high pressure could be maintained without much difficulty. With a blast furnace the difficulties will

be considerably greater. But, above all, it would seem that it has not always been kept clearly in mind that it is the partial pressure of the zinc vapor—not the total pressure in the furnace—which is the decisive element in getting liquid zinc. The case is exactly analogous to that of water vapor in air at 0° C. under atmospheric pressure, mentioned in the last paragraph. Let us assume, for the sake of argument, that if we have nothing but zinc, a pressure of, say, three atmospheres will be sufficient to get metallic zinc in liquid form at the reduction temperature of zinc oxide. Then it would be very wrong to assume that a pressure of three atmospheres, when applied to the blast furnace, would be sufficient. In the blast furnace we have a mixture of zinc and other vapors, and, as may be easily found by calculation, the total pressure will be about seven or nine times the partial pressure of the zinc. Hence to get liquid zinc it will, under these suppositions, be necessary to apply a total pressure of twenty-one to twenty-seven atmospheres. We do not know what results have been or are being obtained with the Lungwitz process on a large scale at Warren, but in view of the above consideration it would be very interesting if such information would be published.

Silicon.

According to the estimate of Dr. F. W. Clarke, of the Geological Survey, silica forms 58.3 per cent (or silicon 27.4 per cent) of the contents of the solid crust of the earth. Only very recently has it become possible to produce silicon by a sufficiently cheap process in the electric furnace, this being another example of the general rule that the conquest of the fixed, very stable and difficulty-transposable compounds of the strong metals is a special domain of electrochemistry. Aluminium is another example; and as was the case with aluminium some ten years ago the chief problem is now to find uses for silicon. So far its main use has been in the metallurgy of iron and copper, and silicon has been applied there in the form of ferro-silicon or copper-silicon on account of the lower melting points. Both ferro-silicon and copper-silicon are also products of the electric furnace. Copper-silicon is produced on a large scale in the Cowles works in Lockport, N. Y., and is also imported and is very largely used to get sound copper castings in order to combine with silicon the oxygen of the cuprous oxide dissolved in the copper. Ferro-silicon is still very largely imported from Europe. The reason given by American manufacturers of other ferro-alloys, is that in the special case of ferro-silicon the cost of power is such a large item of the total cost that with the power prices charged in general in this country it is impossible to compete with manufacturers in mountain regions in France, where power may be had at extremely low prices. The main action of ferro-silicon is assumed to be the same as that of copper-silicon. When used in steel manufacture, the first effect of the silicon is to combine with any oxide of iron remaining in solution in the bath, and thus to prevent the formation of "red short" metal.

* * *

However, it has often been pointed out that this cannot be the only action of the silicon, and that another effect is to increase the solvent power of the steel for the gases—since by direct chemical combination silicon evidently cannot remove hydrogen or nitrogen. The retention or occlusion of gases by iron is well known, but little exact information is available as to the influence of occluded gases on the physical properties of steel, apart, perhaps, from the hardness of electrolytically refined iron, due to occluded hydrogen, and apart from the mechanical defects, such as blow-holes produced by the gases. There is much more research work necessary and it is necessary to approach the problem with as broad a viewpoint as possible. Chemical research cannot reveal everything. It is important to use all methods of physics and physical chemistry. In this respect Mr. Albro's American Electrochemical Society paper, the first part of which is published in this issue, should be welcomed as an important addition to our knowledge on the way silicon influences the microstructure of steel and copper. Some points in this paper are also extremely interesting with respect to the chemistry of silicon.

A Tree Never Quite Grows to Heaven.

Of the men associated with the group of capitalists known as the Standard Oil People in the lane that re-echoes Trinity's chimes, none seems to the public to do his work better than Frank A. Vanderlip, vice-president of the National City Bank of New York. This accomplished gentleman gives out at different times to the public utterances of a judicial character, evincing a practical and theoretical knowledge of political economy that is representatively American. In fact, we would compare his broadness of view in commercial affairs to that of our great electrical engineers, like Steinmetz, who unite a knowledge of "fourth-dimension mathematics" with the ability to build actual machines. Mr. Vanderlip likewise has the gift for expressing his thoughts in clear-cut crystalline English as do our highest type of technical men. In his recent address at Washington before the American Bankers' Association, he sounds a warning against speculation on the street and repeats the sentence, "A tree never quite grows to Heaven" like the ever-recurrent Leitmotiv of a Wagner opera. This warning should be seriously considered in the metal business, for the great increase in metal production, which is so closely intertwined with our country's prosperity, cannot in the nature of things keep on advancing perpetually. The setback is sure to come, and then those concerns that have not progressed conservatively will go to the wall, because of industrial weakness. Another line of thought that appealed to us was his eulogy of the savings and economies effected by the broad management of our trusts. The large corporations are doing in most cases exactly right, trying to keep their business on the basis of large scale production, to be seen in the cost sheet—the supreme court of commerce. It is satisfactory to Americans to see the Teutonic spirit of philosophy applied in a Caledonian practical manner by a representative man of affairs to the actual problems of the day. It makes us think that with all the weaknesses and vices of our crude, virile youth, this country possesses in the American type, seen best in our athletic President, sane and safe qualities for enduring noble life.

William B. Rankine.

Niagara Falls has become the center of electrochemical industries of the world on the basis of its power development, and the Niagara power development on large scale became a fact largely through the enthusiasm, energy and foresighted policy of Mr. William B. Rankine, whose loss we now mourn.

Mr. Rankine died on Sept. 30, at Franconia, N. H., to which place he went for the benefit of his health Aug. 12. The cause of death was congestion of the lungs, superinduced by heart trouble.

Mr. Rankine was born at Owego, Jan. 4, 1858. He was interested in the organization of the Niagara Falls Power Co., and at the time of his death was vice-president of that company and of the Canadian Niagara Power Co., and was in a large number of allied concerns. Besides his wife and mother, he is survived by three brothers, Harold, Delancey and Richard.

Mr. Rankine's father was the Rev. Dr. James Rankine, an Episcopalian minister, at one time president of Hobart College. He entered Hobart in 1873, and left it to go to Union College two years later. While at college he became one of the corporators of the Alpha Delta Phi fraternity. He was graduated in 1877.

For the next four years he lived in Niagara Falls. He then came to New York City and entered the law firm of Vanderpoel, Green & Cummings. Three years later he struck out for himself.

It was while living at Niagara Falls that he first conceived the idea of utilizing the great natural forces in the Niagara River and Falls for the production of power for commercial purposes. While in New York City he met prominent financiers and interested them in his plans. His leading associate and confident was Edward D. Adams, to whom and himself, more than any other men, the modern utilization of Niagara on a grand scale is due. He succeeded in forming a company, called the Niagara Power Co., and became its secretary and treasurer. Later he was made a vice-president.

Mr. Rankine always acted as the chief executive of the company, and spent his time between the works and the main office in New York City. Eventually he went again to live in Niagara Falls.

For many years he was a member of the committee on admissions of the University Club. He also belonged to the Metropolitan Club and the Bar Association. Besides the Niagara Power Co., the Natural Food Co., one of the largest concerns in the city, paid him a salary as a member of its executive committee.

In Feb., 1904, he married Miss Annette Norton, of Detroit, Mich.

The funeral was held at the Episcopal Church, in Niagara Falls. Mr. Rankine had a fine personality and made many strong and warm friendships. His hospitality at Niagara Falls will be remembered by many readers of this tribute to his worth and memory. What he has done for Niagara Falls is history.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

International Electrical Exhibition at Olympia.

From the electrochemical or electrometallurgical standpoint this exhibition is distinctly disappointing, particularly to any who may read the preface to the catalogue of the exhibition, which contains a concise summary of the history of electrochemistry from the pen of Mr. K. R. Swan, a son of Sir Joseph Swan. From the electrochemical point of view the omissions are serious. There are no electric furnaces, no tanks for electrodeposition, and no electrometallurgical products, if one excepts copper, which appears in the form of cables or dynamo windings. No aluminium, no electric steel, no electrically produced chloride of lime or caustic soda or clorates, no calcium carbide, no samples of galvanized articles or deposited copper. There are, however, exhibits of secondary batteries (other than alkaline) on a scale never before attempted, and several pyrometers. In regard to the latter, Messrs. Siemens Bros. & Co., Ltd., exhibited a platinum resistance pyrometer, with a differential galvanometer and direct reading scale. A thermoelectric recording pyrometer with a platinum and platinum-rhodium couple, with a range of 1600° C., was also shown. For the purpose of exhibiting the delicacy of these instruments, the ends of the pyrometer tubes were placed in a small Bunsen furnace. In connection with the recording thermoelectric pyrometer, Messrs. Siemens Bros. supply an automatic commutator which will connect in turn different thermo-couples in different parts of a large factory, each circuit being made for the space of 2 minutes, and an interval of 1 minute being allowed between the records from each couple. Mr. R. W. Paul also exhibited his "universal pyrometer" for measuring temperature of from 100° to 1400° C., in connection with various interchangeable thermocouples. A smaller pyrometer for steam temperatures was also shown, together with an alarm attachment to ring a bell when any given temperature is reached or exceeded.

Gold from Sea Water.

Among the papers read before the recent South African meeting of the British Association for the Advancement of Science—to give that body its official title—special reference must be made to Mr. G. T. Beilby's paper on the subject. For a time, at any rate, Mr. Beilby has given a quietus to schemes for recovering gold from sea water, which contains on the average one grain of gold to the ton, by pointing out that on existing gold fields, with highly trained chemists in charge of works, the cyanide liquor which contains 100 grains or more of gold per ton, and the slimes which contain only eighteen grains or so, when run through the zinc precipitating boxes, issue from those boxes still containing 1.5 grain per ton; and the extraction is not more complete because the chemist cannot make it so, or because a more exhaustive treatment than that which leaves two or three grains per ton behind would not pay. Thus we have the gold seeker intentionally throwing away from his plant as of no further value, although it has already paid its own costs of collection, preparation and passage over the zinc, a liquor which is appreciably richer in gold than the ocean it is proposed to treat. The sea contains only half the metal present in the final effluent of the gold works, and yet it would have to be impounded and handled in a manner that must prove more expensive in labor and material than the simple process of zinc-box precipitation.

The Autumn Meeting of the Iron and Steel Institute.

First Day's Proceedings.

Last year the Autumn meeting of the Iron and Steel Institute was held in the United States, but for the September meeting of this year Sheffield was selected as the place of assembly. A gathering at a center like Sheffield has one advantage over the early summer meetings in London, and that is that, in addition to the reading of papers, various works are open to visits by members of the Institute. As a result, the Sheffield meeting, which was held in the last week in September, was well attended, and Mr. Bennett Brough, the popular and indefatigable secretary, had good cause to be pleased with the success of the meetings.

The papers read on the first day began with Prof. Arnold's account of the "Department of Iron and Steel Metallurgy at the University of Sheffield," narrating the equipment which, in the practical laboratories, contains appliances for producing steel on a manufacturing scale by the three standard methods

of manufacture—crucible, Bessemer and Siemens steels. The crucible plant consists of a 6-foot new form Siemens gas furnace, capable of making heats up to 2½ tons. The Bessemer plant consists of a 1-ton vessel, fitted so as to take a very shallow bottom-blown bath, a side-blown heat by the Roberts modification, or a surface-blown heat by the Tropenas method. The praise which Prof. Turner, of Birmingham; Prof. Wedding, of Charlottenburg, and Prof. Gowland, of London, bestowed upon the equipment is well merited. There seems to be one salient omission, and that is that there are no electric furnaces of any type available for the production of special steels, but that all the alloys produced for investigation are the yield of the crucible furnace.

Thermal Transformations of Carbon Steel.

The second paper, by Prof. Arnold and Mr. McWilliam, on "The Thermal Transformations of Carbon Steel," is of considerable length and rather difficult of concise abstraction. Suffice to say, that steel was considered from the three points of view of saturated, super-saturated and unsaturated steel, and the appearances of ferrite, pearlite, hardenite, cementite, graphite, sorbite, etc., at various temperatures chronicled. A concluding paragraph on micrographic nomenclature may be quoted in extenso, because of a plea for a clearing of the air in regard to this matter.

"The authors earnestly advise students of metallography to keep as closely as possible to the well-established terminology of mineralogists and petrologists. If specific names terminating in 'ite' are indiscriminately given to indefinite transition mixtures of true constituents, the utmost confusion is certain to ensue. It becomes more and more evident that metals are igneous rocks (usually crystalline), and in more senses than one the nomenclature of metallography should be founded on a rock, otherwise the subject will never become a science. The constituents of iron and carbon steels must always be the types with which to compare the micrographic variations caused by the influences of elements other than carbon."

Finally, the authors quote the following words of Prof. Grenville Cole on the subject:

"The study of the igneous rocks has become, unfortunately, so involved in the question of their nomenclature that it is impossible to give an outline of the characters employed in their discrimination without a statement of the sense in which each particular name is used. All these names represent groups of rocks graduating into one another, but certain types can be kept clearly before the mind. When a rock is on the border line between two groups, whether in structure or mineral constitution, we must be content to say so without attempting to disguise natural facts by our classification. Petrography has of late suffered from the introduction of an abundance of new terms, and, what is far worse, of old terms defined in new senses; but the majority of these can be avoided by the use of familiar adjectives or mineral prefixes, to the great lightening of the science."

As might have been anticipated the discussion hinged largely on this virtual question of standardizing scientific terms. For instance, Mr. J. E. Stead advocated the use of the term "austenite," also preferred the words euctectoid, hypo-euctectoid and hyper-euctectoid, to the expression saturated steel used in the paper, and also had a hankering after martensite. Prof. Bauerman appealed for a simplification of the nomenclature used in this work, and urged the abandonment of the insincere use of mineralogical names. Troostite, for example, is the name of a well-known mineral, and now is also applied to some structure about the character of which everybody differed. Prof. Turner, Birmingham, had searched for sorbite in iron, and had not found it. Mr. Lange sympathized with the simplification movement as a practical man as well as from the point of view of the investigator. Mr. McWilliam pointed out that the object of the paper was not to dogmatise, as had been suggested, but to clear matters. Prof. Arnold, in reply, supported his contentions, and said that the misuse of names was really a breach of scientific etiquette. The name sorbite had been adopted with Dr. Sorby's permission to a substance discovered by Prof. Howe, and nobody should appropriate that name for another purpose without permission of Prof. Howe or Dr. Sorby.

Overheated Steel.

The third paper, by Mr. Arthur Windsor Richards and Mr. J. E. Stead, dealt with "Overheated Steel," and contained a detailed examination of a wagon axle (which broke at a flaw after twenty years of use), and was submitted to heat treatment. Subsequently, certain hypothetical conclusions were recited on which the author suggests that an ideal condition would be obtained if free ferrite were absent in carburized steels which have to be subjected to severe vibratory stresses. Ordinary structural steels in this condition can be obtained by heating to a suitable temperature, quenching and reheating at a lower temperature. One of the samples described as sorbitic steel was prepared in that way. It was devoid of free ferrite, and it will be seen that it has double the resisting power of the normal forged bars.

In concluding the authors laid special emphasis upon the fact that they "do not maintain that steel initially bad, brittle and dangerous, owing to irregularity in the distribution of the elements, or from other causes which have not yet been explained, can be made good by any kind of heat treatment. What we believe has been proved conclusively is that good steels which have been heated to any point short of incipient disintegration, and made excessively brittle by such treatment, can be completely restored to perfectly sound and reliable material. Also that it is safest to heat to a temperature about 50° above the critical points to ensure the complete change of every portion of the steel, excepting in the case of the purest and most homogeneous steels, when the temperature of the upper critical points need not be greatly exceeded." A short discussion followed, which does not call for comment.

Vanadium.

The fourth and fifth papers, by Dr. Leon Guillet, respectively, entitled "The Use of Vanadium in Metallurgy," and "Steel Used for Motor Car Construction in France," were then read in abstract by Mr. Brough. The following are the main conclusions respecting the former paper: (1) On normal steels it produces a very distinct increase in the tensile strength and elastic limit, and has no influence, or an insignificant one only, on elongation and contraction and upon resistance to shock. It slightly increases the hardness. (2) On quenched steel, vanadium considerably increases the tensile strength and elastic limit; it acts in this way, with almost as great an effect as carbon, yet notwithstanding this it does not increase the brittleness. The influence of vanadium in metallurgy is thus, in my opinion, of considerable importance. It is undoubtedly the element which, together with carbon, acts with the greatest intensity in the way of improving alloys of iron—that is to say, in very small percentages. It is to be specially noted, however, that alloys of iron, carbon and vanadium are more sensitive to heat treatment and mechanical handling than ordinary steels, but this does not appear to be any longer the case in more complex alloys, particularly in nickel vanadium steels. It remains to consider the influence of the addition of vanadium upon the cost per cent of the vanadium contained. The cost of production of ferro-vanadium is such as readily to allow of its addition, and if, at the moment of writing, the price of ferro-vanadium is still high—about £1 per pound of vanadium contained—this must be attributed to the scanty demand, which is altogether inadequate, and, consequently, entails expenses of manufacture which are spread over but a very small output, thus considerably increasing the price. This state of affairs will disappear when the use of vanadium becomes more widespread. It may be concluded that the employment of vanadium in the

manufacture of special steels is distinctly indicated, particularly in the manufacture of quarternary alloys such as iron-nickel-carbon vanadium.

Steel for Motor Cars.

With regard to Mr. Brough's paper the following summary is all that calls for quotation:

(1) Steels with low percentages of carbon and nickel—pearlitic steels—which are used for parts which require cementing and quenching, *i. e.*, shafts, gears which engage directly, etc. (2) Steels with medium percentages of carbon and low percentages of nickel used, after quenching and reheating, for a large number of parts, shafts, gearing, pinions, etc. (3) Steels low in carbon and with high percentages of nickel, used for valves. (4) Chromium steels, with high carbon and low chromium percentages, used for bearings. (5) Silicon steels, used for springs and for gearing. (6) Nickel chromium steels, with low percentages of nickel and of chromium, employed for numerous parts requiring resistance to shock, and a certain degree of hardness. (7) A new steel known as N Y, the composition of which has not been published.

The subsequent simultaneous discussion of the two papers was mainly confined to manufacturing testimony as to the value of small percentages of vanadium.

The Second Day's Proceedings.

Owing to the restriction of space I can only give the titles of the papers read, and next month will review their scope and the discussion they occasioned. Their titles were as follows: "Segregation in Steel Ingots," by Mr. B. Talbot; "A Manipulator for Steel Bars," by Mr. D. Upton; "The Reversible and Irriversible Transformations of Nickel Steel," by Mons. L. Dumas, and "The Presence of Greenish-Colored Markings in the Fractured Surfaces of Test Pieces," by Capt. H. G. Howorth. The following papers were not verbally discussed in formal session of the Institute, but being taken as read will form the subject of communications in the proceedings: "Wear of Steel Rails on Bridges," by Mr. T. Andrews; "The Nature of Troosite," by Dr. Carl Benedicks; "The Influence of Nickel and Carbon on Iron," by Mr. G. B. Waterhouse; "The Occurrence of Copper, Nickel and Cobalt in American Pig Iron."

The whole meeting had an air of cosmopolitanism, M. Guillet and M. Dumas having contributed papers from Paris, while Dr. Benedicks writes from Sweden, and Mr. Waterhouse and Prof. Campbell come from the United States. The cosmopolitan spirit will be developed to a greater extent next year, when delegates from the American Institute of Mining Engineers and other kindred bodies are coming over for a joint London meeting.

Market Quotations During September.

In one or two instances chemical products have risen during the month. Sulphate of ammonia has risen from £12.11.3 to £12.17.6 per ton. Bleaching powder and the soda products are unchanged. Arsenic (best white powedred) has risen from £13 to £14.10 per ton. Copper sulphate is slightly lower at £21.15. The coal tar products are in several cases a fraction higher. Potassium bicarbonate and caustic potash are lower, fetching £17.5 and £19.5 per ton respectively. Shellac is steady at £9 per cwt.

Copper fell very smartly at the beginning of September to £68 per ton, but recovered slowly to £71.5 by the 29th. Tin has been irregular, closing at £146.18.9. Lead fetches £14.10 per ton. The upward movement in the iron trade is very marked. Hematite rose from 58s. 9d. per ton to 62s. 3d. Cleveland pig iron rose to 50s. per ton, and has since gone higher.

London, Oct. 7.

CORRESPONDENCE.

The Artificial Production of Diamonds.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—In an interesting lecture delivered at the last meeting of the British Association, Sir William Crookes described a new formation of the diamond by the explosion of cordite in closed vessels, where a temperature of over 5000° and a pressure of 50 tons per square inch—conditions necessary for the liquefaction[1] of carbon—were realized.

Although we have made no serious attempt to produce diamonds, a description of some experiments on the solution of carbon in thermit iron may be of interest.

These experiments were performed in clay crucibles which were plunged into water as soon as the reaction was over. The iron was dissolved and the insoluble residue treated in the ordinary way.

We obtained, finally, a small amount of a black powder not attacked by hydrofluoric acid, hot sulphuric and potassium nitrate, boiling nitric and potassium chlorate, etc. The particles were not more than a few tenths of a millimeter in diameter, had a density above three, and disappeared when heated to a high temperature. We could not be certain that they scratched corundum, as they were extremely brittle. Iron, not suddenly cooled, gave no particles which could be mistaken for diamonds. Perhaps thermit under pressure might be used to dissolve carbon; but it would be difficult to attain the calculated critical pressure of carbon.

We have also utilized the heat given out in the thermit reaction for the fusion of silica. Graphite tubes filled with powdered quartz were heated in thermit slag, or were specially protected and heated in the iron. The silica fused nicely, and gave rods with few air bubbles. The expense of manufacturing quartz tubes by this method would be heavy; but some combination of electrical and thermit heating might be profitable.

F. M. G. Johnson.
D. McIntosh.

McGill University, Montreal, Oct. 17, 1905.

Metallurgical Calculations.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I want to express my appreciation of your series of articles by Prof. J. W. Richards on "Metallurgical Calculations."

Prof. Richards' experience with the practical side of this problem, combined with the theoretical side, due to his contact professionally with many large concerns, is well known. This combination of "theory and practice wedded" is the reason for the warm and hearty welcome these articles are receiving.

Almost every metallurgical engineer I have seen recently has spoken to me about them, and we all have agreed that each of us would purchase the volume, when it is published in book form.

It will certainly fill a known want, for we will have in it the data and methods of calculation in handy form, and will be no longer compelled to hunt through a half dozen reference books (sometimes unsuccessfully).

It is a pleasure to give your journal this tribute.

Woolsey McA. Johnson.

New York, Oct. 24, 1905.

[1] Crookes says, "Carbon and arsenic are the only two elements that have a melting point above the boiling point, and, among compounds, carbonic acid and fluoride of silicium are the only bodies with similar properties." Acetylene should be added to the latter group. Since acetylene can be exploded by heat, by detonators or by a "sympathetic" explosion, it might be substituted for cordite, but the pressure produced would not be so great.

A Co-operative Analysis of a Copper Slag.

BY THORN SMITH.

In the *Engineering and Mining Journal* of Feb. 21, 1903, the writer submitted a report on a "Coöperative Analysis of a Copper Slag." The present article is a continuation of the same work, using another sample of slag. In the former article an endeavor was made to make the object of the work plain, yet many critics have persisted in ascribing wholly different intentions. Let it again be stated that the writer is *not* endeavoring to standardize methods for the analysis of slags or any other material, that he is *not* advocating strictly accurate methods for the analysis of the grosser smelter products, and, finally, that he is *not* endeavoring to displace methods now in use. He further wishes it distinctly understood that he is not combating the work of the committee, appointed by the American Chemical Society, on "Uniformity in Technical Analysis." The sole motive in undertaking the work is to make better chemists and to show the need of better chemical work by practical demonstration. It makes no difference whether a chemist is employed in an experiment station or a copper works laboratory, he is at the some time called upon for an accurate analysis, and that the vast majority of chemists are unable to make a strictly accurate analysis is a subject too one-sided for discussion. Steel works, acid works, cement works and the like, can use standard and practically uniform methods to advantage, but many others, including copper works, cannot, except in a few instances. The methods in use at steel works are pretty well standardized, but there is undoubtedly room for further improvement. The cement chemist, working on a comparatively simple material, is unable to agree with his brother chemist, and the need of standard methods, strictly followed, is very urgent. A coöperative scheme, embracing cement work, published two reports, but has now been abandoned for several reasons, chiefly from the fact that the chemists, those who should have been most interested, were not sufficiently alive to the importance of the work.

The writer, after sending out two series of slag, is not discouraged and will continue his work so long as a generous employer and time will permit. If the need of better chemists, better chemicals, better methods, and last, but not least, better work, can be demonstrated, he will feel that his efforts have not been without avail.

The second series of samples was sent out in May, 1903, and the long delay in making this report is due, to a great extent, to the writer's not stating any definite time in which to make returns. Coöperators were requested to do the work at their leisure, consequently the work was put off by a majority until forgotten or interest had died out. Some fifty odd requests for samples were received, which were sent out at no small expense. Of these but fourteen responded with more or less complete analyses. As in the first series the requests came from all over the world. It was hoped that more instructors would respond, but it appears that they were not sufficiently interested, though why is difficult to understand. Many of the letters requesting samples contained useful hints, and every writer seemed to appreciate the need of coöperation. With the sample was sent a tentative scheme of analysis, which was prepared more as a basis of criticism than as a guide to accurate work. The writer was greatly disappointed at the lack of criticism; in fact, practically none was received, although in several instances inaccuracies in the methods proposed were very evident.

To the following chemists the writer is indebted for more or less complete analysis:

O. W. Knight, Bangor, Me.

Percy Morgan, School of Mines, Waihai, Auckland, N. Z.

W. H. Kauffman, American Smelting & Refining Co., Durango, Col.

J. Watson Bain, School of Practical Science, Toronto, Can.

F. X. Mooney, Tennessee Copper Co., Copper Hill, Tenn.

Otto Huschka, Monterey, Mexico.

Nelson T. Hasenpflug, Grasselli, Chemical Co., Cleveland, Ohio.

Chas. E. Rueger, Butte, Mont.

S. H. Worrell, University of Texas Mineral Survey, Austin, Tex.

Thos. B. Swift, Mountain Copper Co., Elizabeth, N. J.

Miss Florence Jackson, Wellesley College, Wellesley, Mass.

H. M. Backus, Orford Copper Co., Bayonne, N. J.

C. A. Bohn, San Luis Potosi, Mexico.

Gino Bagnoli, Orbetello, Italy.

In the following tabulated statement the numbers are attached for convenience of discussion. They have no relation to the order in which the above names are given, beyond the three exceptions to be noted:

COÖPERATION ANALYSES.

Number	SiO_2	Fe	Al_2O_3	CaO	MgO	Mn	Zn	S	Cu
1	25.50	40.86	3.17	8.73	2.13	.37	2.94	2.01	.81
2	25.88	41.05	1.14	9.24	2.13	.65	2.39	1.64	.50
3	25.56	....	....	8.45	1.78	.19	2.91	2.18	1.08
4	25.58	41.58	3.33	3.06	Trace	.43	4.91	1.07	.64
5	25.16	40.62	....	8.61	....	....	....	....	.82
6	26.92	42.05	4.00	8.48	1.23	.66	....	2.01	.77
7	28.30	40.50	....	8.20	....	....	1.80	2.10	...
8	25.46	40.67	3.14	9.71	2.58	.28	3.99	1.97	.79
9	24.69	40.70	....	8.21	....	....	3.47	2.15	.76
10	26.20	40.95	3.95	9.20	....	.50	3.10	2.13	.76
11	25.68	....	....	....	....	....	....	3.89	.87
12	25.53	40.58	3.23	8.84	2.03	.37	2.42	2.17	.81
13	30.00	38.40	....	....	....	....	2.90	2.25	....
14	25.58	40.91	3.51	8.79	2.16	.37	3.31	2.14	.81
15	25.74	....	....	....	2.14	....	....	....	.79

Analysis No. 1 is the work of the writer, and is the results of many hours work. Each constituent was determined several times, and in most instances by different methods. It is not claimed that all of the results are strictly accurate, but it is safe to say that none are in greater error than one-tenth of a per cent. Individuals may disagree with the above statement, but owing to the great discrepancy in the several reports made no *one* individual can dispute the correctness of the writer's analysis. For these reasons it will be assumed as the standard and all comparisons made as such. Nos. 12 and 14 check so closely with that of the writer that he takes the liberty of stating that No. 12 is the work of Chas. Rueger, of Butte, Mont., while No. 14 was reported by Nelson T. Hasenpflug, of Cleveland, Ohio. Both of these chemists have taken the greatest of interest in the work, and the writer is greatly indebted to them not only for the chemical work done but for many useful criticisms.

A comparison of results between the first and second series of slags shows an improvement, but not a marked one. It is possible that the slightly better work shown in this series has come about through a perusal and study of the first, by the chemists coöperating. Attention is called to the fact that but a small number of the chemists reporting on the first series appear in the second. The writer does not believe the chemists reporting on the second series are superior to those of the first. It is not intended to call attention to poor work as a whole, but rather to criticise, in an effort to remedy the cause of divergent results. Inexperience cannot be considered as carelessness, and the writer prefers to ascribe a majority of the poor results, as a whole, to this factor. However, poor work has been done in this series by chemists holding responsible positions with concerns that can afford, and should require, better work.

The most important constituent of a straight copper slag is undoubtedly the copper. Hence the discussion of this element

is given first and somewhat at length. Of the twelve results reported nine are satisfactory, and of these five are as near correct as can be made.

No. 2 reports his results obtained by the electrolytic method, but gives no particulars, hence the low figures cannot be accounted for. No. 3 precipitated the copper with hydrogen sulphide, ignited in a stream of hydrogen and weighed as sulphide. He further checked his result by ignition with ammonium carbonate. He overlooked the fact that lead by this method would be reported with the copper. Attention was called to the small amount of lead present when the samples were sent out. In the case of No. 4 a reason for the discrepancy is difficult to find. A glance at this chemist's work as a whole would lead one to believe it due to a lack of experience. His condemnation of standard and almost necessary methods of analysis shows a lack of something, to say the least. Of the above three chemists not one seems to have had any experience in copper work.

Before continuing the discussion the writer wishes to state briefly a method devised by himself, and which he believes superior to all methods yet proposed, not only as regards accuracy but time, which is of great importance. It permits the handling of a large quantity of slag as easily as a small quantity, and in either case without the accompanying mass of gelatinous silica. Either 5 or 10 grams of slag is weighed into a No. 3 beaker, 100 c. c. of hot water added and brought to a boil. HCl is added, a few c. c. at a time, that the boiling may not be interrupted, the beaker being given a rotary motion until danger of sticking is past. When largely in solution about 100 c. c. additional of hot water is added, and the copper thrown out by a rapid stream of hydrogen sulphide. This will require about five minutes, as the greater part of the iron remains in the ferrous condition. The copper sulphide is caught on a Gooch crucible, using a few drops of hydrofluoric acid to hasten the filtration. The sulphide of copper is then dissolved in nitric acid and bromine, and finally electrolyzed in the usual manner.

No other constituent has so many methods of estimation, and every chemist reporting has a favorite scheme requiring anywhere from one to four hours before it is ready for the battery or titration. No one has ever questioned the writer's scheme as given above, and he asserts that were it more generally used a great saving of time would ensue, and in most cases greater accuracy. Twenty grams have repeatedly been prepared for the battery in less than one-half hour. The precipitation on aluminium is tedious, and a trace or more of copper is almost invariably found in the filtrate, as is admitted by No. 5, who adds .2 of a milligram to his results.

Nos. 8, 9 and 14 used the method of the writer. No. 8 removed from the battery too soon, and determined the copper remaining in the solution by a colorometric method. No. 9 secured a dark deposit, due probably to too strong a current, which never gives perfectly satisfactory results. On dissolving in nitric acid and replating the deposit was bright. The writer intimated to this chemist the probable cause of blackening, but the said chemist refused to admit that the current was stronger than necessary. His statement, however, does not alter the fact that too strong a current will cause blackening of the cathode. No. 14 followed the writer's method exactly, but at the time the analysis was made was inclined to believe a roundabout method, including the complete removal of the iron, would give more accurate results. This chemist was also annoyed by the blackening of the cathodes, but discovered that he was using too strong a current. This blackening is more liable to occur with materials low in copper. It may not be out of place at this point to state that even though the cathode stem does not show a copper stain after raising, the solution should always be tested with hydrogen sulphide water after removing from the battery. Further, that because no copper is deposited on a fresh surface after the lapse of a half hour is no indication that all of the copper has been deposited. Two hours is often necessary. The remaining six chemists determined the copper in various ways. No. 5 took the nitric acid solution down to white fumes with sulphuric acid, and precipitated the copper on aluminium, followed by titration with cyanide in the usual manner. No. 12 took 5 grams down to fumes with sulphuric acid, filtered, dissolved in nitric acid and potassium chlorate, and again took down to fumes with sulphuric acid, then electrolized for twenty hours. No. 15 evaporated 5 grams to dryness without the use of sulphuric acid, took up with hydrochloric and precipitated the copper with hydrogen sulphide, then filtered and ignited the precipitate. Then dissolved in nitric acid and electrolized. No. 11 fused 10 grams with potassium bisulphate and ammonium fluoride, took up with dilute HCl, followed by precipitation with hydrogen sulphide. He then ignited and dissolved in nitric and hydrochloric acids and carried down to white fumes with sulphuric, followed by electrolysis in the usual manner. No. 10 weighed 5 grams into a casserole, added hydrochloric and nitric acids, followed by hydrofluoric, and ran down to white fumes wit hsulphuric acid. Then cooled and added water and strips of aluminium and boiled (!) two hours, and finally added hydrogen sulphide water to complete the precipitation. He then filtered and determined the copper by cyanide. No. 6 reported his result as obtained by the electrolytic method but gave no particulars.

It can readily be seen that all of the above methods give satisfactory results on this particular sample of slag. If time is a factor, and it is so generally considered, then the majority of the chemists reporting used a method requiring too much of a valuable factor. The simpler the method the less the number of details and manipulations, then the more accurate the result. The writer will concede that his method is open to slight improvement, but will not admit that any of the above methods will give more satisfactory or accurate results whatever the time required for the preliminary operation. He further claims that no other method has been published which admits the handling of a large quantity of slag without attending difficulties. Copper is an element that can be estimated accurately, and there is absolutely no excuse for poor results by one who assumes to be familiar with its estimation.

The next constituent to be considered is the silica. Dr. Hillebrand, of the Geological Survey, has done much to put the determination on a more accurate basis, and either many chemists are not reading current chemical literature or are *persisting* in the use of obsolete or inaccurate methods. It has been demonstrated beyond a doubt that a double evaporation and volatilization with hydrofluoric acid is absolutely necessary for the correct estimation of silica. It is true that statements have appeared to the contrary, but the fact is not changed. The results on this slag show what can be done when a definite method is followed. It must also be added that blasting at a high temperature for at least twenty minutes is another essential.

Of the fourteen reports on this element, Nos. 3, 4, 8, 9, 11, 12 and 14 are good, while 5, 10 and 15 are not far wrong. Nos. 6, 7 and 13 are poor, the latter most emphatically so. No. 11 evaporated twice but found no residue on volatilizing with hydrofluoric acid. This surprising statement calls for no comment. No. 7, 10 and 13 evaporated but once, and did not correct by volatilization with hydrofluoric acid. Thus, here are three results, all obtained by the same method, two of them radically wrong and all different. This is the usual method employed in smelter laboratories. Its use is necessary, but it does seem as though greater care might have been employed. Nos. 3 and 5 evaporated once and corrected with hydrofluoric acid. No. 2 and 9 did not specify the method used. No. 6 used a method to which attention was called in the writer's first report, but his result is not in conformity with what should be expected from this method. This chemist took the slag to dryness, dissolved in acid, filtered, ignited, and then fused with sodium carbonate and again ran to dryness.

By this method of procedure we would expect a double loss, yet the result reported is nearly 1½ per cent higher than the standard.

On the whole, the results on silica may be considered fairly satisfactory. The poor results are due, in most cases, to rapid methods, something entirely out of place in an accurate determination. There should be a balancing of errors in any rapid method of estimating silica, if ordinary care is used, but this is not usually found true.

A discussion of the results on iron naturally follows. Probably no element is more difficult of correct determination. This statement will undoubtedly be challenged, yet, until we have a method that can be depended upon, chemists will continue to differ. Iron wire is never pure, and one chemist uses a factor of purity of .996, while another thinks .998 is better. When zinc is used as the reducing agent iron is introduced in varying amounts and a blank is difficult to run. It is true that uniform results can be secured by the individual; but on comparing with another's work there may be a marked difference. The writer uses as a standard an iron ore on which several iron works chemists obtained almost identically the same results. He considers it superior to iron wire or the double salt of iron and ammonia. The method of reduction employed by Dr. Hillebrand is undoubtedly the best. It obviates the possibility of introducing iron or any other contaminating substance. In brief, the sulphuric acid solution of the slag is reduced with hydrogen sulphide, the copper sulphide filtered off, and the excess of hydrogen sulphide removed by boiling in an atmosphere of carbon dioxide. The solution is then cooled and titrated with permanganate in the usual manner. The writer followed this method, and after a little practice was able to produce perfectly satisfactory results. The results given in No. 1 is the average of a large number of determinations varying less than one-tenth between the highest and lowest. He believes his results as accurate as can be made. The method is not adapted to rapid work but is a sure check on the more rapid methods. The fact must be emphasized that by this method the titanium, which is always present in this slag, is not estimated, hence in the following discussion, results which are higher than the standard by one-tenth of a per cent may be considered as correct.

Of the eleven results reported Nos. 2 ,8, 9, 10 and 14 are good, of which No. 10 and 14 are exceptionally so. Nos. 5, 7 and 12 are fair. No. 4 shows results in conformity with the rest of the analysis. Nos. 6 and 13 are also very poor, showing a difference of 3.65 per cent.

No. 2 used the permanganate method but gave no particulars. No. 8 reduced with iron-free zinc (?), and titrated with bichromate. He believed his result a little high, owing to a weaker titrating solution than at first supposed. No. 9 did not state the method used. No. 10 reduced with stannous chloride and titrated with bichromate. No account was taken of the iron held up the silica. No. 14 secured all the iron by fusing the insoluble residue, then precipitated with ammonia, washed well, dissolved in HCl, reduced with stannous chloride and titrated with bichromate. He overlooked the small amount of iron which nearly always passes the filter paper on prolonged washing. This chemist expressed himself as dissatisfied with his standardizing material. Of the fair results No. 5 neglected to take into account the iron retained by the silica, which may vary from a trace to a marked amount, depending on the preliminary treatment. He probably suffered a further loss in throwing out the copper on aluminium. He reduced with zinc and titrated with permanganate. No. 7 used an ordinary rapid method but gave no particulars. No. 12 decomposed with acqua regia and without running to dryness, filtered out the silica and made an ammonia separation Then dissolved in HCl, reduced with stannous chloride and titrated with bichromate. Here should have appeared a loss of iron by that held up by the silica and the great liability of passing through the filter on washing the ammonia precipitate.

Of the poor results, No. 4 used the Zimmerman-Reinhardt method, which, in the opinion of most authorities, does not always give correct results. This chemist also precipitated with ammonia first and washed well. No. 6 precipitated the iron and alumina with ammonia and washed well, dissolved in sulphuric acid and titrated with permanganate, preceded probably by a reduction with zinc. Like several others he overlooked the liability of iron to pass through the filter on washing, but this might have been balanced by the iron in the zinc. No. 13 was obtained by what the chemist called the Colorado practice. On the whole the results on iron may be considered as fair and show improvement over those of the previous series. When all of the possible factors of error are considered it is very probable that a majority of the co-operators could secure first-class results if, in addition, due care were taken. Until we have a definite standard and a definite method of procedure there must follow a lack of uniformity.

Alumina has to bear a heavy load. Practically all of the errors are thrown upon it, and that even passable results can be secured is surprising. The "difference method," in the hands of the average chemist, is worse than useless. There are not a half dozen chemists in the United States to-day who can, by the use of this method, present accurate figures on any material. This statement will, of course, be questioned, but will not alter a fact. Of the whole fourteen chemists reporting on the slag 50 per cent failed to make returns on alumina. The writer naturally concludes that these failures are due to a lack of confidence in the difference method. Yet this lack of confidence was not at all common before the writer published the results on the first series. The method has been in use for years and its correctness seldom questioned. Undoubtedly thousands of analyses have been made in which the alumina has been reported from 25 to 100 per cent more than actually was present. This statement applies to all materials of which alumina is a constituent.

Of the seven who sent in results Nos. 4, 8 and 12 are very close to the standard. No. 14 is not very far out, while Nos. 2, 6 and 10 are not satisfactory.

The standard result was obtained by the phosphate method, which, notwithstanding numerous statements that results obtained by this method are low, the writer is prepared to prove accurate. It may give results low by one-tenth of a per cent, but this can be overlooked in almost any analysis. However, in the hands of a chemist working in the average laboratory the method gives results far superior to the difference method and without the disagreeable odor and taste of the phenylhydrazine method. The only objection in its present state is the great length of time required to wash the precipitate, but this is sure to be overcome shortly.

Of the results close to the Standard, No. 4 was obtained by the phosphate method and checked exactly by the difference method. In view of the fact that this chemist's iron oxide was higher than the standard by 1 per cent it would follow that his good result was an accident. In addition, his method of freeing the iron and alumina from other bases is open to question. The writer can only say that the coincidence was a remarkable balancing of errors. No. 8 obtained his figure by the phosphate method, and the result reported is the average of two widely varying results, hence as given in the tabulated statement is misleading and will not be considered. No. 12 is the work of Mr. Rueger, and is from every point of view the most satisfactory reported, not excepting the standard. Mr. Rueger used a method devised by himself, particulars of which can be found in the *Engineering and Mining Journal* of March 3, 1904. By the indirect or difference method he secured practicall the same results, but as his iron is a little high it would follow that his alumina, by the difference method, would be higher than by his own method. There are, however, so many factors that may cause error in the difference method that the last statement is made with due regard. The rather un-

satisfactory result secured by No. 14 was obtained by the phosphate method. He made but one separation, whereas two are necessary in a material so high in iron. Taking the last statement into consideration the result is satisfactory. Of the unsatisfactory results No. 2 is most decidedly so. The determination was made by the phosphate method, but evidently this chemist's experience with the method was limited. No details were given, hence a criticism must be limited to the above statement. The writer's early experience with the method gave results entirely too low, but with a very little practice satisfactory results became the rule. No. 6 separated the oxides or iron and alumina with sodium hydroxide; he made but one evaporation for silica and precipitated the iron and alumina twice with ammonia. Hence a serious error may have been introduced, at least from failure to evaporate twice for silica. The statement is made in most text books that sodium hydroxide, free from alumina and silica, is difficult to obtain. In the writer's experience he has never found a sample free from these elements. If due preliminary precautions were taken, the sodium hydroxide made in the laboratory by the individual and from the pure metal, using platinum dishes throughout, except for the fusion, the method would give as good results as the best. No. 10 used the phosphate method, but instead of the theoretical factor .4185 he used .45, and this together with but one precipitation is probably the cause of the high result. The high factor was undoubtedly used to offset the low results this method is supposed to give.

As a whole, the results on alumina are far superior to those of the first series. That this is due, in part at least, to the abandonment of the difference method is very evident. This latter method is absolutely worthless as ordinarily practiced. Mr. Rueger's method has not been adversely criticised, but does not give better results, in the writer's hands, than the phosphate method. There is much to be desired in the way of shortening this method, and that this will come in time cannot be doubted.

(*To be concluded.*)

The Ruthenburg and Acheson Furnaces.

By F. A. J. FitzGerald.

An early example of a furnace, in which the material under treatment was heated by passing a current through the charge, was that of Cowles, in which aluminium alloys were made. The objection to a furnace of this type is that an excess of carbon must be used in order to make the charge a conductor of electricity. In making alloys such as ferrosilicon, etc., at the present day, the charge is heated, in part, by means of the current passing through the mixture and in part by an arc, so these furnaces are not purely of the resistance type.

The Ruthenburg Furnace.

There is so much evidence of misconception of the working and object of the Ruthenburg furnace that it seems to be advisable to consider it in some detail. The primary object of this furnace is to agglomerate magnetic iron ore by causing the individual particles of the finely ground material to fuse or frit together, thus forming lumps or masses of relatively large size. This may be done by passing an electric current through a mass of ore; but since the granular ore is a very poor conductor of electricity it is necessary to use a furnace in which the cross-section is very large compared to the length. Moreover, it is not desirable to fuse the ore into large, solid lumps, but merely to frit it together so that a quantity of the treated material will form a porous mass.

The Ruthenburg furnace consists of a powerful electromagnet in horse-shoe form, the poles of the magnet being electrically insulated from one another, since they form the terminals of the furnace. The magnetite, in a finely ground condition, is fed between the poles of the magnet and held there, forming a bridge which connects the poles electrically. The poles are connected to a source of current which thus passes through the bridge of ore. Now it is evident that in a circuit of this kind the places of highest electrical resistance will be at the points of contact of the ore grains, consequently, it is at these points that the greatest generation of heat will occur, thus causing the grains of ore to fuse together. The heat generated at the points of contact is conducted into the bodies of the grains themselves, thus raising the whole mass to a bright, red heat. At this temperature the magnetism of the ore disappears, and the fritted mass falls from the poles of the magnet.

The rest of the process has nothing to do with electric furnaces; but it may be mentioned that the scheme is to cause the heated ore to fall from the poles of the magnet into a suitable receptacle, carefully insulated, so that the heat given to the ore is not allowed to escape, and then to pass reducing agents, such as carbon monoxide, through the porous mass, with the object of reducing it to metallic iron.

Mr. Ruthenburg has asserted that in working his furnace he uses only 250 kw-hours per ton of ore, and this has caused much adverse criticism, due to a misunderstanding of the nature of the process. It must be remembered that the mass of ore is not fused, but merely agglomerated and raised to a temperature at which reduction with carbon monoxide gas will occur. The fusing temperature is only reached at the points of contact of the ore grains. Keeping this in mind it may easily be shown that no extraordinary efficiency of working is demanded by Ruthenburg's assertion.

Let it be assumed that the ore mass is to be raised to a temperature of 1000° C., and that the specific heat of magnetite is 0.154. Then if W is the watt-hours required to raise 1 kilo. of ore from 0° to 1000°, and there is no loss of heat, we have:

$$W = \frac{4.2 \times 0.154 \times 1000 \times 1000}{3600} = 180$$

Where 4.2 is the conversion constant.

For a ton of 2000 pounds of ore the energy required under the assumed conditions would be 164 kw-hours. Thus, Ruthenburg's assertion only demands an efficiency of 65.6 per cent, which does not seem to be impossible. It should be noted that the specific heat of magnetite used in this calculation is that determined by Kopp, between 18° and 45°. It may be that the average value between 0° and 1000° is greater than this, and if so, the efficiency called for is greater.

The Acheson Graphite Furnace.

The Ruthenburg furnace shows clearly the great advantage of having a material in granular form when it is desired to heat it electrically for, as is well known, magnetite in a fused form is a comparatively good conductor of electricity. This is further illustrated in the Acheson furnace for converting carbon into graphite where the heating is done by passing the current through the charge. Here again the main generation of heat occurs at the points of contact of the individual grains of carbon.

In the earliest patent connected with the Acheson process of manufacturing graphite[1] the object is the purification of impure carbonaceous materials, such as ordinary coke, by heating these in a granular form to such a high temperature that the impurities, silicon, iron, aluminium, etc., are volatilized. In the subsequent patents, relating more especially to the manufacture of graphite from anthracite coal[2], and the process of converting petroleum coke into graphite[3] the volatilization of impurities also enters in. The theory of the Acheson process is that graphitization is brought about by the formation and subsequent decomposition of carbides, hence a carbon-

[1] U. S. Patent No. 542,982, July 23, 1895.
[2] U. S. Patent No. 645,285, March 13, 1900.
[3] U. S. Patent No. 711,103, October 14, 1903.

aceous material, such as anthracite coal, is chosen, because it contains a certain quantity of carbide-forming materials distributed throughout it. On the other hand, when a very pure carbon, such as petroleum coke, is employed, the carbide-forming substance is mixed with the charge. The various reactions which occur in the furnace undoubtedly take place at widely different temperatures, the absorption and release of heat energy that accompany the chemical changes are unknown quantities; finally, the temperature of the furnace is unknown, so it is obviously a hopeless task to make any estimate of efficiency.


E. G. ACHESON.

As to the furnace used for converting carbon into graphite the only published information is that supplied in the patent[4] on making graphite from petroleum coke. The furnace is described as having a length of 30 feet, and a sectional area of 18 by 14 inches. The loss of heat by radiation from a furnace of these proportions must be considerable. In the case of a furnace of rhomboidal form, as near an approach as possible to a cube should be made in its construction, since that rhomboid presents the smallest surface for a given volume. The furnace described in the patent contains a charge of 52.5 cubic feet. In the form of a cube this volume would have a surface area of 84 square feet; but with the dimensions given the surface is 164 square feet. Therefore, other conditions being the same, the radiation losses would be nearly double in the case of the furnace described as compared with a furnace of cubical form. The difficulty encountered in approaching the cubical form is found in the low electrical resistivity ultimately produced in the charge. At first the resistivity of the charge is so high that a resistor, in the form of carbon rods embedded in the charge, is used to connect the terminals of the furnace, and the current is confined nearly altogether to this resistor. But as the surrounding charge becomes hot, and the carbon is converted into graphite, its conductivity is greatly increased, so that finally the whole mass becomes a conductor. By regulating the voltage at the terminals of the furnace the power is kept constant; but in order to do this with a shorter furnace than that described in the patent, it would be necessary to use a lower voltage and larger current than is at present the practice.

In the present state of our knowledge we are ignorant of what the losses by radiation in furnaces of this type are, hence it is impossible to say what gain in efficiency would be obtained by approaching more closely the ideal form. Study of this point would be very useful. Let it be assumed that the furnace described above uses 750 kw. and that when the highest temperature is reached a current of 7500 amps. at 100 volts is used. From these data it may be calculated that if a current of 15,000 amps. at 50 volts could be obtained, the dimensions of the furnace would be: length, 15 feet; sectional area, 24 by 21 inches. This would give a surface to the charge of 119 square feet. Similarly, with 30,000 amps. at 25 volts the dimensions would be: length, 7.5 feet; sectional area, 36 by 28 inches, giving a surface of 96 square feet. These furnaces, more nearly approaching the cubical form, would be more expensive to install than the furnace described in the patent, because it would be necessary to use much more copper, in order to carry the currents of large ampereage. Moreover, it would be more difficult to obtain a good power factor in the furnace circuit. Still another point to be kept in mind is the increased size of the furnace terminals, which, being good conductors of heat as well as electricity, would increase heat losses in that way. The important thing to determine, however, is where the greatest efficiency is obtained.

Electrode Furnace.

It was originally proposed to graphitize carbon articles by the Acheson process in a furnace where the articles were embedded in powdered carbon[5], but in a later patent[6] an improved method of heating electrodes to the graphitizing temperature is described. In Fig. 1 is shown a vertical longitudinal section of the furnace, where *c c* are the terminals, *e* the carbon electrodes arranged in piles, *g* granular carbon, *h* refractory lining, *i* covering material of ground coke and sand. It will be observed that when the current is thrown on, it passes alternately through sections of the furnace filled with granular carbon or electrodes, and as the resistivity of a mass of the granular carbon is very much greater than that of the electrode the chief generation of heat takes place in the former. Herein lies the chief feature of the invention, for by this ingnious arrangement the use of currents of very low voltage and enormous ampereage is avoided.

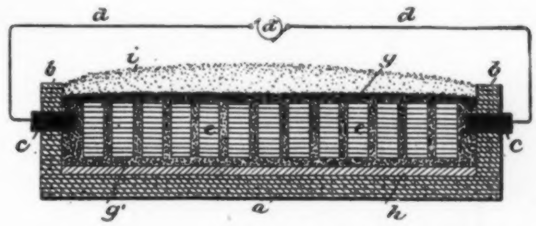


FIG. 1.—LONGITUDINAL SECTION OF ELECTRODE FURNACE.

Details of the construction of an electrode furnace are given in the patent specifications, and from these the following table has been drawn up:

Distance between terminals of furnace	360 inches
Length of space filled by electrodes	302 "
Length of space filled by granular carbon	58 "
Length of electrodes under treatment	24 "
Width of electrodes under treatment	5 "
Height of pile of electrodes	17 "
Initial voltage	210 volts
Initial ampereage	1,400 amps.
Volts at end of five hours	210 volts
Amperes at end of five hours	3,600 amps.
Final voltage	80 volts
Final ampereage	9,000 amps.

From this table we may calculate the resistance of the furnace at various stages of the run, assuming that if the volts and amperes were obtained from a voltmeter and ammeter, respectively, the power factor is 1:

	Ohm.
Resistance of furnace, initial	0.150
Resistance of furnace at end of five hours	0.058
Resistance of furnace, final	0.0089

For the resistivity, *i. e.*, the resistance of 1-inch cube of the electrodes we have the following data, assuming that at the end of five hours the electrodes have been heated to a temperature where their resistivity is reduced one-half:

	Ohm.
Resistivity of electrodes, initial, cold	0.00124
Resistivity of electrodes at end of five hours, hot	0.00062
Resistivity of electrodes, final, graphite	0.00032

[4] Ibid and "Electrochemical Industry," Vol. 1, No. 4, p. 130.

[5] U. S. Patent No. 617,979, January 17, 1899.

[6] U. S. Patent No. 702,758, June 17, 1902.

To calculate the resistance of the electrodes in the furnace we have the equation:

$$R = P \frac{l}{A}$$

where R is resistance, P resistivity, l length and A sectional area. From the first table we find that the total length of the space filled with electrodes is 302 inches, and the sectional area $17 \times 24 = 408$ inches. Thence the following table is obtained:

Resistance of electrodes in furnace,	Ohm.
Initial	0.00092
End of five hours	0.00046
Final	0.00024

Since the energy developed in any part of the furnace is given by the product of the resistance and the square of the current, we have the following table for the distribution of energy:

	Granular Carbon.	Electrodes.
	Kws.	Kws.
Initial	293.82	0.18
At end of five hours	750.05	5.95
Final	700.56	19.44

It should be noted that the resistivity of the graphitized electrodes assumed in the calculations is that found at ordinary temperatures. It is, of course, different when the electrode is hot; but this would not seriously affect the results given in the last table, which shows clearly the important part played by the granular carbon in the working of the furnace. When the carbon electrodes to be graphitized have a circular cross-section the furnace is built as shown in Fig. 2, since with this form sufficient resistance is obtained at the points of contact of the electrodes.

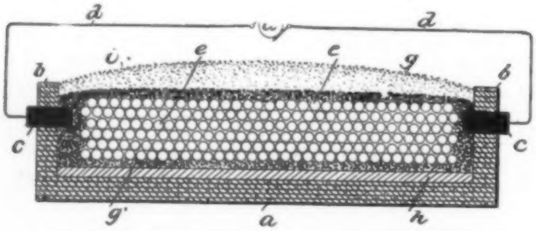


FIG. 2.—FURNACE FOR CIRCULAR GRAPHITE ELECTRODE.

New Assay Furnace Tools for Works Laboratories.

In our September issue we published the first part of a paper recently presented by Dr. EDWARD KELLER before the American Institute of Mining Engineers on labor-saving appliances, devised by the author for the Baltimore laboratory of the Anaconda Copper Mining Co. On account of limitations of space we had to hold over the description of Dr. Keller's new assay furnace tools, which is herewith given.

The implements used in performing the furnace work in assaying are shown in Fig. 1. A and B are the traditional tongs, universally used for handling singly the scorifiers and the cupels. The former has been entirely replaced with a fork C, with which a set of twenty scorifiers can be handled at one time. In silver assaying each set of scorifiers is placed in the muffle twice and taken out twice; first put in the muffle for the incineration of the filters, then taken out for the addition of the test-lead, then returned for scorification, and finally taken out for pouring the slag and molten lead into the molds. By the use of the fork, which works perfectly if the muffle be properly supported so that it will not sag to any marked extent, sixty handlings are reduced to three.

Four scorifiers, constituting a longitudinal row in the muffle, are poured at one time by means of a pair of tongs D, and with a little practice the pouring is made just as easy as with a single scorifier. It is necessary only that the mold correspond to the arrangement of the scorifiers and that the pockets are shallow.

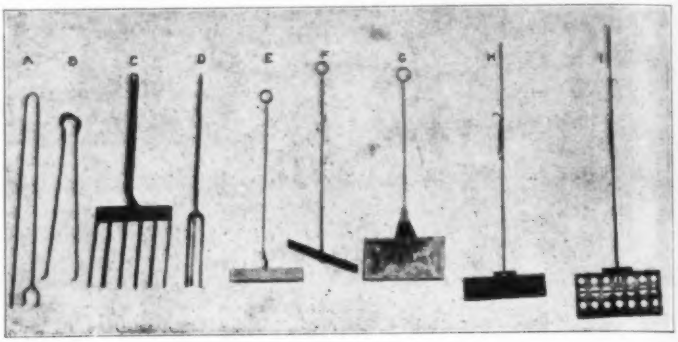


FIG. 1.—ASSAY FURNACE TOOLS.

The cupels are placed into, or taken from, the muffle in sets of one or more rows, by means of the tools E, F and G, an idea which was first put into practice by the author's brother, Richard Keller, of Durango, Col. E and G are sharp-edged shovels, the latter having upturned sides. F is a rabel, with which the cupels are raked onto the shovel, removed therefrom to the place where they are to be deposited by placing it behind them and withdrawing the shovel.

The tool H and I is entirely new, and by its use one or more rows of cupels in the muffle may be charged with the lead-buttons from the scorifiers. Fig. 2 shows the idea of the device more clearly. It comprises a top sliding-plate with openings corresponding exactly to the position of the cupels. The openings in the lower plate correspond exactly with those of the upper one; the plate, however, rests on two adjacent sides extended downward at right-angles to the plate and to each other, thus forming two closed sides of the instrument, one at the front, and the other at the right-hand side. The height of these sides is such that, when resting on the bottom of the muffle, the bottom plate will be some distance above the cupels and, by a slight pull forward and a push to the left with the handle of the instrument, the set of cupels will be perfectly aligned in both directions, and the apertures in the lower plate will exactly cover the tops of the cupels.

The lead-buttons are placed in the apertures of the upper plates and rest on the lower plate before introducing the instrument into the furnace, and when it is placed over the cupels, which have been properly aligned in the muffle, the upper plate is pushed forward to a stop-point, bringing the

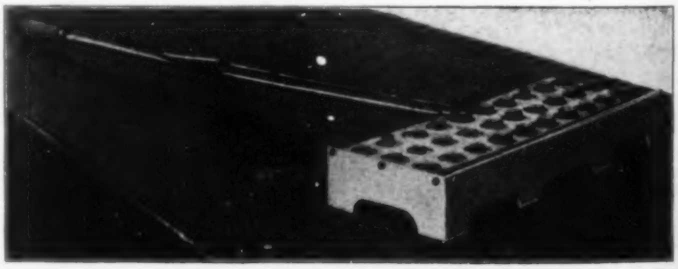


FIG. 2.—DEVICE FOR CHARGING SCORIFIER BUTTONS INTO CUPELS.

apertures of the two plates to register, thus causing the lead-buttons to drop down into the cupels. The handle of the upper plate runs through guides fixed to the handle of the lower plate; both handles are connected by a spring, which acts as a brake when the upper plate is pushed forward to drop the buttons, and also serves to bring it back into its original position, in which the buttons cannot drop through the apertures in the lower plate.

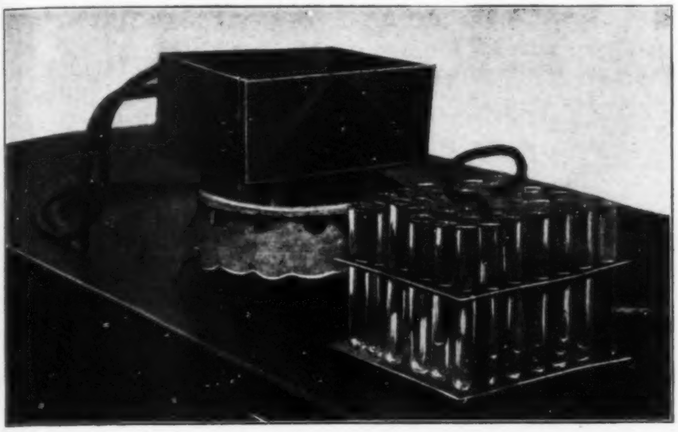


FIG. 3.—CONVENIENT PARTING BATH.

Charles Tookey[1] first recommended the use of hydrochloric acid ($1HCLaq,2H_2O$) instead of a brush for cleaning the buttons, and for this purpose a small silver dish and tray having perforated pockets give excellent satisfaction. By the use of this device fifty or more beads at a time can be treated, washed and dried without transfer.

Fig. 3 shows a very handy parting-bath, which though old in principle has not been in general use. The vessel is a constant-level water bath, and the tray an ordinary test-tube holder. The silver beads to be parted are dropped into the test-tubes, and the latter filled with dilute nitric acid of a strength of one of acid (sp. gr. 1.42) to nine of water. The water in the bath is first brought to the boiling point before the tray with its contents is set into it. Treated in this way, the gold almost invariably remains in the form of a small coherent bead, even from an alloy as low as one part of gold to 500 of silver.

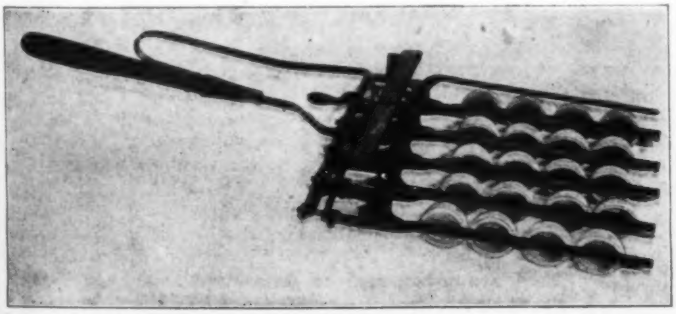


FIG. 5.—MULTIPLE TONGS; SCORIFIERS TIPPED FOR POURING CONTENTS.

Dr. Keller recognized that the system of handling everything in sets was incomplete as long as he was unable to take a whole set (twenty) scorifiers from the muffle and pour their contents simultaneously into the molds. Recently a tool for that purpose, shown in Figs. 4 and 5, has been perfected. It is composed of multiple tongs, corresponding to the five longitudinal rows of scorifiers in the muffle. The lower part of each pair of tongs consists of a fork, on which the scorifiers rest, and one of whose prongs is rectilinearly extended through two bearings in a frame, and held in position by collars. This extension is free to revolve in the bearings, and it is the axis of rotation of the tongs. To each of them is attached, at right angle, a lever, extending upward at an angle of 45°, and all the levers are connected by slotted joints to a cross-rod. Therefore, if by means of a crank, fastened to the end of one of the extended prongs, one of the forks is turned and the scorifiers tilted to the desired angle, the others perform the same rotation. The center of gravity of the scorifiers lies to one side of the rotation point, and they would, therefore, on being lifted, tilt in that direction; this, however, being prevented by the cross-bar resting against a post at that end of the frame toward which the inclination tends.

The scorifiers are clutched by the upper prong of the tongs, which is fastened to a spring on a post of the fork below, and which is free to move in a vertical plane, the pivotal point

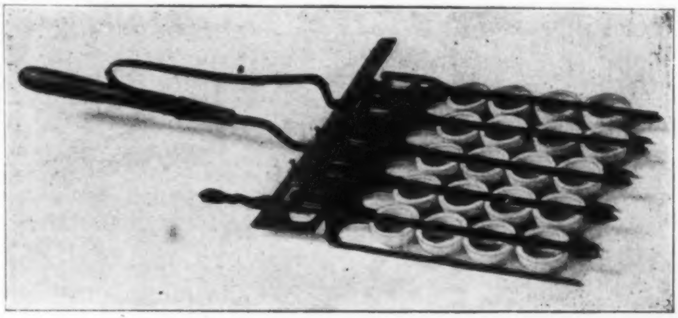


FIG. 4.—MULTIPLE TONGS; SCORIFIERS IN POSITION FOR REMOVAL FROM FURNACE.

lying over the spring and post. By bringing pressure on the extended ends of these clutch bars behind the pivot, their other end will rise from above the scorifiers, and thus release these, or permit the placing of them onto the tongs. The pressure exerted on the rear ends of the clutches is accomplished by means of a cross-bar fastened to a spring-bar, which is itself riveted to the handle of the instrument; all of which may be plainly discerned in the illustrations. In pouring the contents of the scorifiers, the frame of the tool rests on the edge of the mold, leaving the tongs free to turn.

The introduction of these new labor-saving appliances in Dr. Keller's laboratory has resulted in economy in several ways. Much labor has been saved; breakage of expensive glassware has been very largely eliminated, and the time of the furnace work, and, consequently, the consumption of gas has been much reduced. Furthermore, the gain has been a moral one, and work formerly regarded as tedious has become more of a pleasure; especially has the sojourn in the furnace room during the hot summer months been rendered cooler by being greatly shortened.

The appliances described in Dr. Keller's paper may eliminate the laboratory boy; but if not, they will make him more reliable. They also increase enormously the quantity of chemical

[1] Journal of the Chemical Society (London), vol. 23, page 366 (1870).

work that one man can do in a day. In the domain of Dr. Keller's own laboratory the change from the old system to the new is considered to bear about the same relation as the change from ancient horse-car to the modern rapid transit.

The Electrochemistry of the Metallic Arc.

By Isador Ladoff.

(Concluded from page 342.)

Observing the metallic arc, produced by a high tension, alternating current in a mirror rotating with a suitable angular velocity, many periods of the alternating current may be distinguished. In the middle of each period a maximum of light is noticeable, and then a lowered luminosity to the end of the period is to be observed. The color of the copper arc under these conditions appeared yellowish-red and violet. In the middle or interval between two periods there was a dark space followed by a bright white scarlet. The last was the discharge spark relighting the arc, extinguished at the end of each half period. Blondel was the first to point out, that a high tension is necessary to relight the metallic arc.

Guye and Monasch (Ecl. El. 35, p. 18, 1904) showed that in metallic arcs produced by high tension, alternating currents, the tensions after a certain distance between the electrodes is reached, increase with diminishing length of the arc instead of dropping when the current is kept constant, and called this zone in which the arc shows this unexpected behavior "the critical zone." In the silver and copper arc the increase of tension is so high in the "critical zone," that no measurements can be taken. However, the "critical zone" appears only in short arcs. It was determined by Guye and Monasch for silver, copper, gold, platinum, nickel, aluminium, magnesium, cadmium and chemically pure iron.

The appearance of such short arcs is different from those of longer dimensions. It produces a slight humming noise, due to the change of periods in the "normal" zone, but causes a sharp hissing sound in the "critical" zone. The only metal not showing any "critical" zone was iron containing carbon. In the last the tension dropped with the diminishing length of the arc if the current was kept constant and everything was normal. However the "critical" zone appeared in chemically pure iron.

The "critical" zone appeared only in pure metallic electrodes of a length of 0 to 3 mm. The presence of carbon in the electrodes does away with the "critical" zone entirely, and the "normal" zone starts with O length of the arc. The reflection of a metallic arc in the "critical" zone in a rotating mirror represented an irregular sequence of bright and dark spaces. Under identical conditions a carbon arc did not show any discontinuity. Monasch (Dissertation Darmstadt 13, 7, 1903) demonstrates the discontinuity of the arc between pure metals in the "critical" zone with the aid of Tomasina's electroradiophone. The telephone of the electroradiophone produced sounds when the arc produced between pure metals was shorter than 3 mm., and there were discontinuous discharges in the arc. In a carbon arc of the same length the telephone remained mute.

In this brief review we will have to pass in silence some interesting phenomena in the arc between a metallic and a carbon electrode.

However our review would be incomplete if we would not say a few words of the arc in metallic vapors in an exhausted space.

We will follow the investigation of E. Weintraub (Philosophical Magazine VI., Series H38 Feb., 1904, Vol. 7).

The different methods by means of which a mercury arc can be started in an exhausted tube may be summarized as follows:

1. Bringing the cathode into contact with the anode and separating the two electrodes.
2. Application of high voltage to the two electrodes.
3. Bringing a cathode in contact with an already active electrode (E. Weintraub's method).
4. Mere mechanical agitation.
5. Contact of the cathode with ionized vapor (Weintraub's method) (p. 101).

In consequence of the high vacuum and volatility of mercury, the arc can be made of any desired length. In common with all the arcs, the voltage across the mercury arc varies only little with the current. If, for instance, the current increases four times, the voltage will vary by only 5 to 6 per cent. In the first approximation, therefore, the *resistance of the arc can be considered as inversely proportional to the current.* In contradiction to the ordinary carbon arc, however, the voltage varies in the same sense as the current (p. 105). The conductivity and the luminosity of the mercury arc do not go parallel, the *maximum conductivity nearly coincides with the minimum light emission* (p. 107). To be perfectly correct we ought to distinguish between three kinds of mercury vapors in the arc stream; one ionized and conductive, the other non-conductive, but light-emitting, and third, non-conductive and non-luminous ordinary mercurey vapor (p. 108).

There is strong evidence in favor of the assumption that the cathode is the electrode at which the primary generation of ions takes place (p. 111). The anode must have a relatively high melting point, must not enter into combination with mercury, must have in its normal condition as little gas occluded as possible, etc. The material of it does not seem, however, to affect the nature of the arc in the least. The action of the magnetic field on the arc is very peculiar and not easily accounted for. The observed phenomenon can be briefly described as follows: The field and the arc being both horizontal and perpendicular to each other, the arc is deflected up or downward, according to the common rule of the action of the magnetic field on a current. The deflection downward is accompanied by a motion of the bright cathode spot along the surface of the cathode in the direction of the current; the arc is thus lengthened, and when it reaches the wall of the tube it digs into the mercury where the latter is in contact with the walls of the tube. If the direction of the current in the arc is reversed, the arc is pushed upward and thus tends to become as short as it possibly can, so that the spot on the cathode moves in the same direction as before. Changing the direction of the field changes, of course, the direction in which the arc is deflected, as well as that in which the cathode spot moves (p. 113).

The characteristic of arcs in vapors of alkali metals except the spectrum, are essentially the same as those of the mercury arc. The electrodes possess the same properties. The potential drop across the arc is of the same magnitude as in the mercury arc. The amount of light given off is very slight.

The alternating current phenomena in the mercury arc, although very interesting from both scientific and technical point of view, do not concern us much here.

Metallic oxides giving electrolytic arcs deserve our attention next.

E. Rasch (Elect. t. Zeitschrift, Berlin, 22, p. 155, 1901) produced arcs between electrodes of magnesia, calcium oxide, oxide of thorium and oxide of Zirconium and arrived at the conclusion that the arc produced by these oxides shows a great luminous efficiency. The oxides used by Rasch belong to the conductors of the second class, which, as is known, do not conduct while cold. With increasing temperature their resistance diminishes. An arc between them may be produced after the electrodes were raised to a certain temperature. Rasch, therefore, proposed to accomplish this preliminary raise of the temperature of the electrodes by means of an ordinary carbon arc. Some metallic oxides, metallic silicides and

metallic borides possess a high melting point and a high temperature of evaporation, and their arcs are determined by a high temperature, especially in the tips of the electrodes.

The spectrum of the electrolytic arc contains few ultra but mostly light-giving yellow-green rays. Especially magnesium and zirconium oxide are claimed to approach sunlight in their character.

Rasch makes the distinction between electrolytic pencils possessing very high resistance while cold, "hard electrodes" and electrolytic pencils possessing moderate resistance. When cold, "soft electrodes." The arc of "soft electrodes" is as unsteadily as metallic arcs. Rasch did not succeed to ascertain in soft electrodes any increase of tension parallel to the increase of the length of the arc. This may be due to the difficulty of taking exact measurements of tension on account of the softening of the tips of the electrodes in the arc. Rasch determined the relation between current, tension and length of arc according to Thomson's formula $E = a + \frac{CL}{J}$ giving the value for "a" = 31.35 volts.

Nernst (Electroch. Zeitschrift, Berlin 22, p. 256, 1901) found in his experiments with "soft electrodes" a great loss through the "burning of material" (Abbrand) in the arc, and what is especially remarkable, that *the consumption of the negative electrode is stronger than of the positive, just the reverse of the carbon pencil.*

There were many attempts to utilize the electrolytic arc as a source of light, attempts that crystalized in a number of patents, but did not lead to any technical success. The fundamental idea of all these attempts to utilize the electrolytic arc for lighting purposes consists in the combination of the oxides possessing lumeniferous properties with non-luminiferous but more conductive oxides. Some inventors went even so far as to propose to make the surface of the pencils conductive by surrounding them with a metallic tube or wire net, or even reducing the oxide *on the surface* to a metallic state.

My own experiments seemed to me to prove conclusively that only titanium (zirconium appears to be excluded on account of commercial considerations) alloyed with some other well conducting metal, for instance, copper or iron, promises to be an ideal material for arc-light pencils. (*Electrical World and Engineer*, Vol. 45, p. 757, 1905.)

The light produced by titanium pencils is agreeable to the eye and pure white in color, and produces the entire spectrum, with especial luminosity in the yellow zone.

The candle-power efficiency of titanium pencils is very high. At corresponding current values and voltages the energy consumption per mean spherical candle-power is from one-third to one-fourth of that required by carbon electrodes.

The light from the titanium arc, as shown by the distribution curves, is produced in about equal amounts above and below the horizontal. It will be necessary, therefore, to use a lamp with a reflector to obtain the best results of illumination.

When operated under proper conditions, the life of the titanium pencils is much greater per inch of material than carbons. The rutile pencil gives longer life than the ferro-titanium, and with the former there is no doubt that a pencil can be designed to give as long a life as the present inclosed arc lamp.

The light efficiency of the ferro-titanium pencil is higher than the rutile, but the difference is so slight that the superior life of the rutile makes it more desirable.

Very superior results are obtained by using titanium pencils in both electrodes. While objections to this might be revealed by further investigation, or an electrode of some other material might be found to give equally good results, this method of operation offers a promising field for investigation. For the same degree of illumination the use of these pencils will reduce the consumption of energy from one-third to one-half that used in the present carbon arc lamps.

The Application of Peat-Fuel.

By L. A. Stillings, Ph. D.

The advisability of seeking cheaper fuel for use in many industrial plants is more than ever apparent in those sections of the country where water-power is not abundant. Competition is growing, and unless the poorly located manufacturer can obtain a cheaper fuel as a substitute for water-power, only the manufacturer who is able to locate or transfer his plant to a water-powered locality will be able to stand the general decrease in price of production.

The great value of peat-fuel is unknown to the average person in the United States. We do not yet appreciate the vast resources offered all over the country for a cheap, clean fuel. When we find that the United States has more than 100 times the acreage of peat to that of all Europe and that Europe has been to a great extent dependent on peat as a fuel for many years, and, at that, only used up a small portion of its peat bogs, we can see the immense future of such a fuel in this country—either in connection with steam or gas power plants.

Since the present use of peat as a fuel will touch only those factories already equipped for steam power, I shall dwell at greater length on those processes. The smaller factories will do well to try the raw peat, while I should advise the larger ones to use the coked product or to refit their works with gas apparatus.

The cost of fuel is governed by its heat and waste. The use of both coal and wood is very wasteful, only a comparatively small part of the heat units being utilized. With coal the clinkers, with wood the live embers which drop through the grate are an additional source of loss. When peat is first placed on the gate it burns with a short, blue flame, which gradually becomes a yellowish glow. It emits an intense heat which is easily controlled by draughts. A peat fire will burn until utterly exhausted, and is nearly smokeless and ashless. The smoke of peat, unlike other fuels, is good for the lungs, and serves as an excellent deodorizer.

The use of peat as a fuel dates back many centuries. The ancient Roman naturalist, Pliny, tells us of Teutonic tribes on the borders of the North Sea, who dried and burned "mud" (peat). In the last century, when fuel for steam engines was required on a larger scale, and, in very late years, high prices of coal have attracted a renewed and most active attention to the use of peat.

The bogs in which peat is contained cover vast areas in the north temperate latitudes, both in Europe and the United States. In Germany they cover nearly 30,000 square kilometers (11,580 square miles), and in Ireland almost one-tenth the entire country. The depth is very variable, but is on an average 5 to 7 meters (about 16 to 23 feet) and more. There are bogs existing in Ireland 15 meters deep (nearly 50 feet). It may be estimated that 1 square kilometer (0.386 square mile) of 5 meters (16.4 feet) depth will give about 700,000 metric tons of dried peat, hence it will be seen that the amount of fuel in these bogs is enormous.

Peat is decaying vegetable matter which in centuries of time would become a form of coal. This organic decomposition is best expressed by the equation:

$$6C_6H_{10}O_5 = 7CO_2 + 3CH_4 + 14H_2O + C_{26}H_{20}O_2$$

Carbon dioxide and methane (marsh gas) being given off, and the resulting mass in water being peat. Eventually, through the pressure and heat generated, this would become coal. The approximate percentage composition of peat is: 16.4 per cent water, 41.0 per cent carbon, 4.32 per cent hydrogen, 23.8 per cent oxygen, 2.6 per cent nitrogen, 11.9 per cent ash constituent, with a specific gravity of 1.05. Sulphur is almost never found. The ash constituent will vary from a small fraction of 1 per cent up to 15 per cent, the average of the

peats of the United States being 3.07 per cent, while that of the German peats is 7.9 per cent.

Peat as a fuel ranks next in order after lignite, in fact, it is of similar construction, and only differs in being of a more recent geologic formation. It contains more water and is but slightly carbonized, and, therefore, has a correspondingly lower thermal value.

Peat is known in general as the rich, dark brown mud found in marsh and swamp lands. However, one should not forget that all rich earth in which plant life grows readily is a form of peat, and will be easily burned if it is carefully dried.

The European peats are mostly composed of decayed mosses and grasses. In the United States we have several kinds of peat. The main one, however, is like the European peats, and is composed of decayed sphagnaceæ. On the Atlantic sea coast we have a variety of so-called "salt march" which produces a peat which would not be of any use for our purposes of fuel. In Europe we have the general term "turf" (German torf) applied to peat.

In the chemistry of the earlier nineteenth century there were many queer analyses of peat. The term "humus" was applied to the deep-brown earth of the bogs, and according to analysis was composed of humic acid. Later, humic acid was found to be a comopund of rather complex nature, which they called crenic and apocrenic acids. The great bogs of this country are: the Dismal Swamps of Virginia, the Everglades of Florida, the Savannahs and rice swamps of Georgia, the great lagoons of the South and the vast sycamore and cedar swamps of the West. Almost all of New England is one vast peat bog. These bogs are coal measures in the primary process of formation. All coal has been mud, and hence, many kinds of mud can now be converted into a substitute for coal. The great value of one of the component parts of peat has only recently been investigated. There is a substance called "pentosane," which comes naturally in all peat and which serves as a natural binder under compression. Its exact nature has not been worked out, as we cannot isolate it or make any compounds with it.

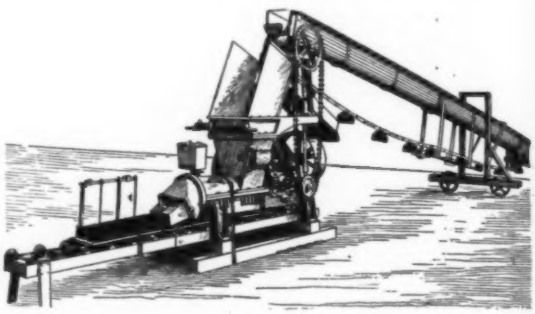
Peat is all organic matter, formed from mosses and other minor plant life which are submerged in water, and thus preserved in the bogs. As it stands, the greater part is water, only about 10 per cent being dry matter. In its use, therefore, much water must be removed, and this is the main difficulty in manufacturing. The general rule is to "air-dry" and then finish by pressure and a slight raising of the temperature. In almost all districts the peat is spread out on the surface of the bog; only in certain very rainy countries, as in Bavaria, Styria and Western Norway, shelters are sometimes used. Peat thus dried in the air will contain 20 per cent to 40 per cent of water.

The ancient method of digging peat was by hand, a special form of spade, called a "slane," being used, which cut a block of a special size. Hand-cut peat is still much harvested in farming regions. When cut by hand, peat is of a very loose consistency and of large bulk, a hectoliter weighing 20 kilograme (12 pounds per cubic foot). This would make it necessary to cut 9 cubic feet to equal 1 cubic foot of coal, and transportation, storage and fire room would have to be larger in proportion.

In order to reduce the volume, peat-milling or crushing machines are now commonly used. In these machines the fibers are torn apart, the mass kneaded, mixed and pressed together, water removed and the volume reduced to about one-eighth of the original. Thus the peat gains a very compact form, and bears a close resemblance to the form of coal known as lignite, both in appearance and density. Peat thus dried is not hygroscopic, and only contains about 20 per cent water. The peat is sometimes used in this form. However, the general procedure is to vaporize the amount of water remaining by a slow heat and leave the briquettes in the hard, bone-dry state in which the greatest efficiency is shown.

Most of the machines knead the peat as it is taken from the bog, taking it up in an elevator or chain of buckets to the mixer, and then it is forced through a mouth piece, which gives it the shape of the briquette and chops them off at a given length. This block is called "compressed peat" (German presstorf). It is wet and soft, and is passed on in this state to a drying table or plain. The first of these machines was constructed in 1861, by C. Schlickeysen, in Berlin. The modern machines are all modifications of his design.

The Schlickeysen process may be described as follows: Raw turf comes up on an endless belt running in the long, sloping trough which leads to the peat bog (for these machines are generally portable, and set up on the edge of the bog and moved from one part to the other as the work of



SCHLICKEYSEN BRIQUETTE MACHINE.

taking the peat out progresses). From the summit of the elevator the raw material drops into the machine, where it is kneaded, cut, torn and compressed into about two-thirds of its original bulk, and delivered at the mouth of the machine in blocks or bricks of any desired size or shape. These are first dried until they lose about two-thirds of their water, and then the drying is continued by artificial means until they are bone-dry. The principle upon which this machine is operated depends on the fact that peat is almost 80 per cent water in its original state, of which four-fifths is held in mechanical suspension between the hairy fibers, and the remaining fifth is contained in the capillary tube running through the hairy vegetable fibers of the peat. Nine cubic feet of raw peat is thus converted by this machine into 6 cubic feet of prepared peat which still contains 20 per cent water. This is further dried and compressed into 1 cubic foot of black, fossil-vegetable stone of about 1.5 specific gravity, which can be sawed, planed and even polished like cannel coal. Such briquettes contain about 66 per cent of inflammable matter, and approximately about 96 per cent the heat value of lignite.

The Stauber process was worked out at Charlottenburg in 1901. The briquette made by this process contains 45.14 per cent fixed carbon, 4.54 per cent hydrogen, 29.34 per cent oxygen, 9.09 per cent ash constituent. It has a thermal value of 3,806 calories. The process includes a method for the rapid drying of the moist peat by means of heated and compressed air within the closed chamber or channel communicating with conduits in such a manner, heater air can be forced out of the drying chamber and condenses it in the conduits, this greatly stimulating the process of evaporation by which the peat is dried. Peat is quickly and properly made into briquettes by this process. The machine consists of a cylindrical boiler with conduit pipes, and has a capacity of turning out 5 tons of completed fuel in a day. The briquette device is the same as the other general types of briquette machinery.

The Schoening-Fritz process consists in compressing dried peat between hot rollers, by which it is simultaneously carbonized and briquetted.

The present style of machine may be simple or very elabo-

rate, some moving from place to place under their own power. Samples and pictures of all types of peat digging and briquetting machinery may be seen at the warerooms of Julius Bordollo, at Kingsbridge, N .Y.

One modification of the processes generally in use is to pump the peat in an almost liquid state from the bog through pipe lines to the place where the pressing and drying machinery is located. This method is greatly used in Sweden and Norway.

Any one of the above processes may be used for small factories, but the following process, known as the Ziegler process, will be found the most suitable and economical for the large works. The Ziegler process was invented by Martin Ziegler in 1892, and was the outcome of many years of hard study and research:

Concisely stated, the Ziegler process consists in carbonizing the peat in closed ovens, heated by burning the gases generated in the coking process itself. Such a plant is, therefore, self-supporting, the only fuel required being coal or wood sufficient to start the ovens for the first charge, when the gases generated by the coking process becomes available and enable the operator to continue the production indefinitely. Not only this, but the off-heat from the retort is passed on to the drying chambers, and serves to dry the wet peat as it is taken from the bogs. This feature presents the most economical way of preparing the wet peat for carbonization.

By the Ziegler process, 1 ton of peat will produce 350 kilograms of peat-coke, 40 kilograms of tar, 6 kilograms of methyl alcohol, 4 kilograms of ammonium sulphates, 6 kilograms of acetate of lime. Hence, from the present market reports we can see that the by-products will pay for the process of getting out the peat-coke and leave a fair margin of profit. The Ziegler process is in great use in Germany and Russia. In Germany, at Oldenburg, there has been a five-oven plant working since 1893, and showing a large profit. At Redkino, in Russia, the government has a station, which they are increasing all the time, with the idea in view of supplying all the locomotives with coke instead of wood and coal to burn. This has been very successful, and the work is very interesting from the steam engineer's end.

In Western Norway, near Bergen, a peat-coking plant has been erected built on different lines. This plant is furnished with electricity, and the electricity takes the place of the fire. This method gives a coke which is even superior to that made by the Ziegler process.

The final and best way for the utilization of peat as power is that of transforming it into gas and using this generator gas in the gas motors or engines of to-day. This process consists in placing air-dried, machine-treated peat in gas generators, preferably such as are described in the *Zeitschrift für Electrotechnik* (Vienna) of Sept., 1905, by Arnold Zlamal, or any of the retorts in use here for making producer-gas. The gas thus generated is stored in tanks or gasometers and piped to the engines, sometimes for long distances. This is by far the most economical method of utilizing a low-cost fuel yet placed before the public, and will become of more general use as the years go by.

The cost of producing peat-fuel is very low, in all the cases mentioned the cost not exceeding $2 per ton delivered. In such processes as the Ziegler, the initial cost is greater, but the sale of by-products reduces the cost of the fuel to a minimum, and in time the profit side appears and pays for the initial expense. This has been proven in the case of the Oldenburg plant. One man can dig with a peat digger about 5 tons of raw peat in an 8-hour day. Therefore, any ten men could dig a sufficient amount to run a plant for some few days.. The saving in any plant should amount in one year's time to the cost of the machinery required to make the peat fuel.

It should be remembered that all analyses go to show that any portion of our country contains bogs of higher thermal value than any of those existing in Europe.

The Microstructure of Silicon and Alloys Containing Silicon.[1]

By A. B. Albro.

Introduction.

This paper is written, not to propose or to defend any theories, but to show photographically recorded facts.

Enough discordant theories regarding the effects of silicon upon metals have already been advanced. For example:

(*a*) Von Jonstorff[2] claims that increasing the silicon in steel increases its brittleness, while Hadfield[3] states that 2 per cent of silicon with about 1 per cent of carbon increases the toughness of the steel considerably.

(*b*) Carnot and Goutal[4] state that silicon usually exists free in cast iron, and that any silicide formed in the furnace disappears on cooling the iron, and in proof of their claims quote the results of Le Chatelier's[5] experiments on the electrical resistance of steel and iron containing silicon, while Stead[6] states that silicide of iron dissolved in iron is one of the constituents of the phosphoric eutectic in gray silicious pig irons.

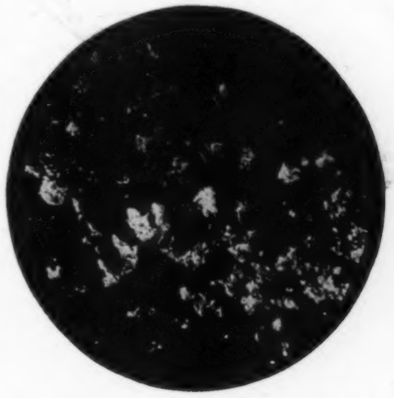


FIG. 1.—GRAPHITOIDAL SILICON × 23.

Others might be quoted regarding the effect of silicon on the properties of the phosphoric eutectic, the melting point and fluidity of cast iron and steel, and various other properties of iron and its alloys, but the above serve to show the considerable disagreement among authorities.

In contrasts with this, the belief that silicon reduces the percentage of iron carbide in pig iron is universally held. Moissan's[7] concise statement of this phenomenon is as follows: " * * * * * silicon displaces carbon in iron and iron carbide. These bodies when maintained at sufficient temperatures behave exactly as the aqueous solution of certain compounds in which

FIG. 2.—SILICON CRYSTALS × 34.

[1]A paper presented before the American Electrochemical Society, Boston meeting .

[2]Report presented at Third International Congress of Chemists at Vienna. Stahl und Eisen, March 7 and 15, 1899.

[3]Reprint of paper read at Institute of Civil Engineers. The Metallographist, vol. 1, pages 135, 136.

[4]Annales des Mines, October, 1900.

[5]Translation in American Manufacturers, Feb. 12, 1903, from Comptes Rendus.

[6]Journal Iron and Steel Institute, 1900, No. 11.

[7]Moissan, Electric Furnace, Eng. edition, page 60.

FIG. 3.—SILICON CRYSTALS × 23.

FIG. 4.—SILICON SURFACE CRYSTALS × 8.

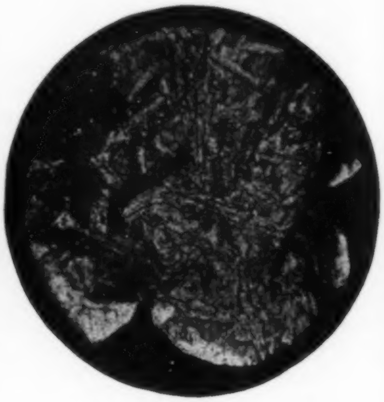


FIG. 5.—SILICON NODULE × 5.

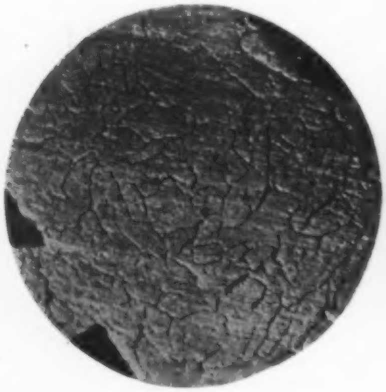


FIG. 6.—SILICON NODULE × 8.

FIG. 7.—SILICON NODULE, VERTICAL SECTION × 8.

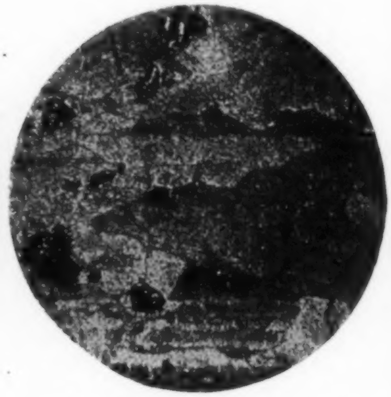


FIG. 8.—SILICON NODULE, HORIZONTAL SECTION × 8.

FIG. 9.—DISTORTED NODULE V × 89.

FIG. 10.—"A" SILICON, VERTICAL SECTION × 8.

FIG. 11.—"A" SILICON, HORIZONTAL SECTION × 8.

we precipitate or displace substances in solution or combination. If the displacement of the carbon is not entirely complete a state of equilibrium is established between the silicide and carbide of iron, an equilibrium in which the conditions vary with the temperature and with the impurities which are contained in the bath. This is generally the case with white or gray cast iron."

Most investigators agree that the presence of silicon lessens the liability of blow-holes, and thus promotes soundness in cast iron and steel, but they differ greatly as to how this result is attained.

Undoubtedly some of the diversity of opinion concerning the effects of silicon is due to certain observers attributing to it the bad qualities of its oxy-compounds.

Iron containing up to about 14 per cent silicon can be produced in blast furnaces.

The electric furnace is capable, under proper conditions and expert manipulation, of producing ferro-silicon of any percentage composition, and recently silicon, practically free from iron, has been produced in commercial quantities by the reduction of silica by calcium carbide or by carbon.

In Europe the process of Scheid is in operation, while in this country the work of Mr. Tone has recently attracted considerable attention.

A novel silicon process has been devised for Mr. George Westinghouse by Mr. Henry Noel Potter, under whose direction these investigations were made.

SILICON.

Fig. 1 shows graphitoidal silicon magnified 23 diameters. This sample was furnished by Mr. Frederic S. Hyde, and was from the original material made by him and described in his article on graphitoidal silicon.[2] To the unaided eye it has the appearance of coarse graphite flakes, and in Fig. 1 it is seen to consist of irregular shaped masses, some of which have plane surfaces.

The silicon needle-like crystals shown in Fig. 2 were also furnished by Mr. Hyde, and are here magnified 34 diameters. These needles were made by solution and crystallization in molten zinc. The actual length of these crystals is about 1 millimeter.

Fig. 3 shows three complex crystals of pure silicon, magnification 23 diameters, made by dissolving pure silicon in molten zinc. The pure silicon was obtained from crystalline silicon which had been very finely powdered and then purified and washed. Only the particles which remained in suspension for 48 hours were used. The resulting powder analyzed 99.8 per cent silicon, gave absolutely no gritty sensation when placed between the teeth, and showed very few crystals under a magnification of 205 diameters.

These complex crystals resemble very much the dendrites of alpha iron shown and described by Osmond and Cartaud.[3] Their actual length was from 1.5 to 2.5 millimeters. The same zinc solution also contained single octahedra of silicon.

When fused in the electric arc furnace, silicon collects in the fluid phase, and in its subsequent solidification extrudes some silicon in the form of worm-like nodules. The surface of these nodules exhibits fern-like crystals, and Fig. 4 shows them magnified 8 diameters. Single crystals have been observed which measured 15 by 50 millimeters.

Before passing to the internal structure of silicon, a word regarding the method of preparing sections for examination is in order. Samples are ground on a carborundum wheel until the desired section is reached, and then ground to a plane surface on a glass plate with "FFF" carborundum powder and water. The last stages of preparation are like those of ordinary steel sections. Etching is done with dilute mixed hydrofluoric and nitric acids in the case of all silicon sections, but the etching acid differs with alloy sections, and will be stated for each one.

In the case of silicon there is a difference between the appearance of a section cut vertically and one cut horizontally through a mass of nodule, and it is, therefore, necessary to know how the mass lay while cooling and to state which sections are vertical and which horizontal.

All photomicrographs having a magnification less than 167 diameters were taken with oblique light, the higher enlargements with vertical illumination. The source of light was a single-glower, 50-candle-power Nernst lamp, with globe removed. This gives a very even illumination of such intensity that with a 1-6 inch objective and 2-inch eyepiece, the exposure necessary with Seed "L" orthochromatic plates ranges from 10 to 60 seconds.

Fig. 5 shows a vertical section of a nodule strongly etched and under a magnification of 5 diameters.

Fig. 6 shows a horizontal section of a nodule strongly etched, and then repolished to bring out only the division lines between individual grains. This shows clearly where impurities at certain places between the grains have been etched away. Magnification 8 diameters.

Fig. 7 shows a slightly etched vertical section of a similar nodule, and Fig. 8 a horizontal section under the same treatment. The dark areas in No. 8 are actual blow-holes, and no nodule was found whose central horizontal plane was free from them. Magnification in both cases 8 diameters.

A peculiar formation noticed in one case under a magnification of 89 diameters is shown in Fig. 9. It is a slightly etched vertical section of a nodule which had been twisted once around its horizontal axis during the formative period.

Owing to the fact that the nodules are under stress during freezing, the crystalline structure is probably distorted, and we should expect to find an undistorted structure only in sections taken from an unstrained mass in the interior of a large block of material.

The next few figures show such interior sections under different magnifications. They are from three samples of silicon called A, B and C.

Sample A was from a 500-pound lot purchased in France in March, 1904, and contains 92.6 per cent silicon, the balance being mainly calcium, iron and aluminium.

Sample B was very kindly furnished by Mr. Frank J. Tone, of the Carborundum Co., of Niagara Falls.

Sample C was made by Mr. Potter, and contains 98.8 per cent silicon, the balance being iron and aluminium.

The next two photomicrographs show sample A magnified 8 diameters. Fig. 10 is a vertical section showing the junction of two masses partially fused together. Long, irregularly overlapping and interlocking grains are seen, many of which seem to have two faces shown in this section.

In Fig. 11, which is a horizontal section, these apparently two-faced grains are shown more clearly, and several triangles are formed by them. In this appearance the section resembles, in a striking degree, the fern-leaf surface crystals shown in Fig. 6. In addition to these, several of the interlocking grains can be seen, but very much shorter than in the vertical plane.

This difference in length of grains viewed vertically and horizontally tends to explain why large masses of silicon fracture much more easily in the plane vertical to the surface uppermost during solidification. It is practically impossible to produce two parallel fractures in the horizontal plane, while this can be readily done in the vertical plane.

Fig. 12 shows a horizontal section of sample B, magnified 8 diameters. This is seen to consist of two large, irregular-shaped grains, together with several smaller ones. In the neighborhood of the smaller grains, silicon carbide crystals are seen.

Sample C, next shown (Fig. 13, 8 diameters), is characterized by its large grains, it being impossible to include a complete grain in the field, 7.6 mm. in diameter, covered by this photograph. The interlocking of the grains is very clearly shown, as well as their homogeneity and the absence of any impurities between them.

The next three slides show horizontal sections magnified 34 diameters.

No. 14 is sample A, and shows the interlocking grains and impurity pits. No. 15 is sample B, and shows a smooth, homogeneous field with the exception of the three areas containing silicon carbide. No area could be found which was free from this compound. In No. 16, which is sample C, a remarkable interlocking of the two dark grains with the H-shaped light green is shown. The field shows such a homogeneity that it can safely be called a photomicrograph of absolutely pure silicon.

The ultimate structure is approached in the next three figures, in which the three samples are shown magnified 167 diameters.

Fig. 17, sample A, shows a very close-grained surface with some octahedra in various portions, but the structure has not the clearness that purer silicon possesses.

In Fig. 18 we have sample B, and this shows a field of pure silicon, with one area containing silicon carbide. Individual crystals can be distinguished here, together with numerous striated areas.

[2]Journal Am. Chem. Soc., vol. 21, No. 8, August, 1899.
[3]Annales des Mines, August, 1900.

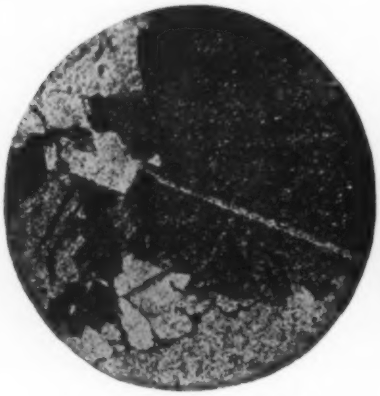


FIG. 12.—"B" SILICON × 8.

FIG. 13.—"C" SILICON × 8.

FIG. 14.—"A" SILICON × 34.

FIG. 15.—"B" SILICON × 34.

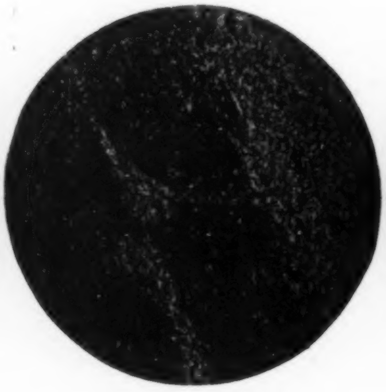


FIG. 16.—"C" SILICON × 34.

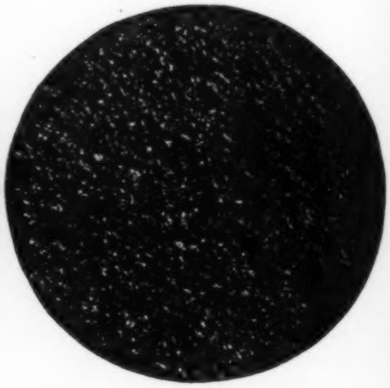


FIG. 17.—"A" SILICON V × 167.

FIG. 18.—"B" SILICON V × 167.

FIG. 19.—"C" SILICON V × 167.

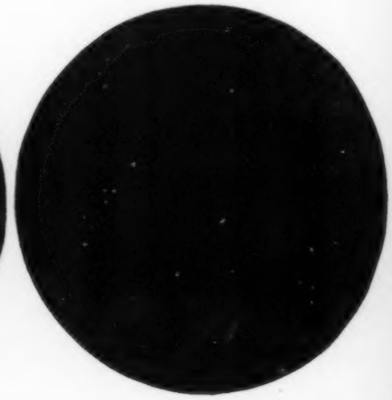


FIG. 20.—"C" SILICON V × 1025.

Sample C, as shown in Fig. 19, shows the structure more clearly than No. 18, and at the same time is free from any impurities. Numerous octahedra and clearly striated areas are visible.

With this latter section under a magnification of 1,025 diameters, as shown in Fig. 20, we have the characteristic silicon cystals.

Despite the slight lack of clearness, octahedra are clearly shown which are striated on the surface, the striations overlapping each other like shingles on a house, the same structure, as Stead observed in his sample of steel, containing 4 per cent of silicon.[10] The structure of silicon does not appear to be affected by any temperature below its freezing point, as the grains and crystals have the same appearance when quenched at a bright red heat as when the cooling occupies 24 hours.

This may explain why the structure of steels containing 4 per cent of silicon is unaffected by heating to 1,100° C., as stated by Stead[11] and others.

[10]Reprint of paper read before Iron and Steel Institute, May, 1898. The Metallographist, vol. 1, pages 327, 328.

[11]Iron and Steel Institute, May, 1898.

(*To be concluded.*)

Metallurgical Calculations.—IX.

By J. W. Richards, Ph. D.
Professor of Metallurgy in Lehigh University.

ARTIFICIAL FURNACE GAS.

There are many different forms of producers for making artificial furnace gas. For the purposes of making calculations upon them they may be conveniently divided into four classes, as follows:

1. Simple producers, those which use ordinary fuels, such as wood, peat, lignite, bituminous coal or anthracite, and in which no water or water vapor is introduced other than the water in the fuel itself and the normal moisture of the air used.

2. Mixed gas producers, in which water vapor or steam is introduced with the air for combustion, in such amount as to be entirely decomposed in passing through the fuel.

3. Mond gas producers, in which, for a special purpose, more steam is introduced than can be decomposed in the producer, thus producing very wet gas.

4. Water gas producers, in which air and steam alone are alternately fed to the producer, the former for heating up, the latter for producing water gas.

As far as the calculations are concerned, the essential difference between these classes is the varying amount of water vapor or steam introduced under the fuel bed while producing the gas, from all air in Class 1 to all steam in Class 4.

The calculations which it is of immediate interest to make, and the results of which are of immediate value to the metallurgist, are those concerned with the volume of gas produced per unit of fuel, its calorific power compared to that of the fuel from which it is produced, the items of the heat losses during the operation of transforming the solid fuel into gaseous fuel, the function of steam in the producer, the limits up to which the use of steam is permissible, the increase of efficiency of the gas by subsequently drying it, the advantages as to final efficiency which are gained by gasifying the fuel over burning solid fuel directly.

For information as to the construction and operation of gas producers, reference may be made to treatises such as Sexton's "Fuel," Sexton's "Producer Gas," Groves and Thorp's "Chemical Technology, Vol. V., Fuels." Trade pamphlets and catalogues, such as those of R. D. Wood & Co., of the De la Vergne Machine Co., of the Wellman-Seaver-Morgan Co., the Colorado Iron Works Co., the Weber Gas & Gasoline Engine Co., the Morgan Construction Co., etc., contain a great deal of exact and useful information, and may be usually had for the asking. The monograph of Jüptner and Toldt on "Generatoren und Martinöfen" (Felix, Leipzig, 1900), is concerned wholly with calorimetric calculations concerning the production of gas and its utilization in regenerative gas furnaces.

1.—Simple Producers.

In these a deep bed of fuel is burnt by air or fan blast, introducing no more moisture than happens to be in the atmosphere at the time being. The fuel fed into the producer is first dried by the hot gases, then is heated and distilled or coked, and finally is oxidized by the incoming air. The residue is the ash of the coal, which is ground out at the bottom or drops through the grate, containing more or less unburnt fixed carbon. Great loss of efficiency sometimes occurs from the ashes being rich in carbon. The escaping gases issue at temperatures of 300° up to 1000° C., carrying much sensible heat out of the producer.

Calculations as to the amount of gas produced per unit of fuel consumed are to be based entirely on the carbon. The gas must be carefully analyzed, so that it can be calculated from this analysis how much carbon, in weight, is contained in a given volume of gas. (An alternative method is to take a carefully measured volume of the gas, mix it with excess of oxygen, and explode in a gas burette, determining the amount of carbon dioxide formed, and from that calculate the weight of carbon in the volume of gas taken.) Knowing this, the rest is simple: the carbon in unit weight of fuel minus the carbon lost in the ashes by poor combustion, gives the weight of carbon gasified; this divided by the weight of carbon in unit volume of gas produced, gives the volume of the latter per unit weight of fuel.

Illustration: A fuel used in a gas producer contains 12 per cent of *ash* and 72 per cent of carbon. The *ashes* made contain 20 per cent of unburnt carbon; the gas produced contains by analysis and calculation 0.162 ounce of carbon per cubic foot of gas, measured at 60° F. and 29.8 inches barometric pressure. What volume of gas, measured at above conditions, is being produced per ton of 2240 pounds of coal used?

Solution: The distinction between *ash* and *ashes* must be noted; the former is the analytical expression for the amount of inorganic material left after complete combustion during the chemical analysis; the latter term means the waste matter produced industrially, and consists, if weighed dry, of the true ash, plus any unburnt carbon. The calculations are therefore as follows:

		Lbs.
Ash in 2240 pounds of coal $= 2240 \times 0.12$	=	268.8
Ashes corresponding $= 268.8 \div 0.80$	=	336.0
(the ashes are 80 per cent ash)		
Carbon in the ashes	=	67.2
Carbon in the coal $= 2240 \times 0.72$	=	1612.8
Carbon going into the gas (gasified)	=	1545.6
Carbon in 1 cubic foot of gas $= 0.162 \div 16$	=	0.010125
Volume of gas produced per 2240 pounds of coal $= 1545.6 \div 0.010125$	=	152,652 cu. ft.

It will be noted that these calculations absolutely require the percentage of *total* carbon in the fuel, as determined by chemical analysis. This is not a difficult analysis, as it consists in burning the carbon in a heated tube in a stream of oxygen or air free from carbon dioxide; the products of combustion are dried and then passed through caustic potash solution to absorb CO^2 gas, the weight of which is obtained by the increased weight of the potash bulb, and the total carbon thus obtained. The fixed carbon and volatile matter of the coal, as determined by the ordinary proximate analysis, cannot be used in this calculation, since while all the fixed carbon is carbon, the volatile matter is of variable composition, containing such varying proportions of carbon that no fixed percentage of the latter in it can be assumed without considerable possible error.

The calorific power of the gas, per cubic meter or cubic foot, can be calculated from its analysis, using the calorific powers of the combustible constituents as already given in our tables. This, multiplied by the volume of gas produced per unit of coal, gives the calorific power of the gas as compared with that of the coal from which it is made. The difference is the heat loss in the operation of producing the gas, including loss by unburnt carbon in the ashes. In fact, we may state that the heat balance is based on the following equations:

Heating power of the coal, per unit
— Heating power of the gas per unit of coal
= Calorific losses in conversion.

The latter item is composed of:

Loss by unburnt carbon in the ashes.
Sensible heat of the hot gases issuing.
Heat conducted to the ground.
Heat radiated to the air.

These items may be modified as follows: If the air used is hotter than the normal outside temperature, its sensible heat above this datum should be added to the heating power of the coal, because it increases the total available heat. If the ashes are removed hot, and not allowed to be completely cooled by the incoming air, their sensible heat should be included in the

calorific losses during conversion. If the air used is moist, its moisture will be decomposed to hydrogen and oxygen, but the heat absorbed in doing this is exactly represented by the calorific power of this increased amount of hydrogen in the gases, and the heat absorbed is not lost but really represents so much saved as available calorific power of the gases. This item must, therefore, *not* be counted as one of the heat losses during the operation, as those losses have been defined by us. If the fuel is wet, considerable heat is required to evaporate the moisture in it, but this heat is *not* to be reckoned as one of the losses in conversion, if we have taken as the heating power of the coal the practical metallurgical value; that is, its value assuming all the water in its products of combustion to remain as vapor and none to condense. If this value has been so taken, the heat required to vaporize the moisture in the coal will have already been allowed for. Similarly, it may take a little heat energy to break up a bituminous coal so as to expel its volatile matter, but this should not be reckoned in as a heat loss in the producer, because a little reflection will show that, whatever this amount may be, it has been properly allowed for in the determination or calculation of the total calorific power of the fuel. Jüptner and Toldt call this the "gasifying heat," and use it in all their calculations, but it is doubtful whether it really amounts to an appreciable quantity, for one thing, and even if it does it should not be reckoned as a heat loss in the producer.

Problem 14.

Jüptner and Toldt ran a gas producer with lignite of the following composition: (*Generatoren*, p. 49.)

Carbon	69.83	per cent
Hydrogen	4.33	"
Nitrogen	0.50	"
Oxygen	12.38	"
Moisture	7.25	"
Ash	5.71	"

Of this coal, 3214 kilograms was used in 8 hours, 50 minutes, producing gas which contained, analyzed dry, by volume:

Carbon dioxide, CO^2	5.21	per cent
Carbon monoxide, CO	23.99	"
Oxygen, O^2	0.63	"
Methane, CH^4	0.25	"
Hydrogen, H^2	10.64	"
Nitrogen, N^2	59.28	"

The ashes produced weighed 22.23 kilograms per 100 kilograms of coal used, and contained 68.76 per cent of unburned carbon. The calorific power of the coal, determined in the calorimetric bomb (in compressed oxygen, moisture resulting condensed) was 6949 Calories per gramme. Temperature of hot gases, 282° C.; temperature of air used, 9° C.; humidity, 76 per cent; barometer, 712 millimeters of mercury.

Required:

1. The volume of gas, measured at 0° and 760 mm. pressure (and assumed dry), produced per metric ton (1000 kilos. = 2204 pounds) of fuel used.
2. The calorific power of the coal, per kilogram, with moisture formed by its combustion assumed uncondensed.
3. The proportion of the calorific power of the coal developable by burning the gas produced from it.
4. The loss of heat in conversion.
5. The loss of heat by unburnt carbon in the ashes.
6. The loss of heat as sensible heat in the gases.
7. The loss of heat by radiation and conduction, expressed:
   (*a*) Per unit of coal burnt.
   (*b*) Per minute.
8. The volume of air required by the producer, at the conditions of the atmosphere, per kilogram of coal burnt.

Solution:

(1) The gas contains, per cubic meter at standard conditions:

Carbon in CO^2 0.0521×0.54 kilos.
Carbon in CO 0.2399×0.54 "
Carbon in CH^4 0.0025×0.54 "

Total $0.2945 \times 0.54 = 0.1590$ kilos.

The carbon gasified from 1000 kilograms of coal is:

Carbon in coal $= 698.3$ kilos.
Carbon in ashes $222.3 \times 0.6876 = 152.8$ "

Carbon gasified $= 545.5$ "

Therefore,

$$\text{Gas (dry) produced} = \frac{545.5}{0.1590} = 3430 \text{ cubic meters.} \quad (1)$$

(2) The calorific power of the coal as given must be diminished by the heat required to vaporize all the moisture formed by its combustion, leaving such moisture as theoretical moisture at 0° C. There will be formed per kilogram of coal:

From moisture of coal $= 0.0725$ kilos.
From hydrogen $0.0433 \times 9 = 0.3897$ "

Total $= 0.4622$ "

To evaporate this to theoretical moisture at zero (thus putting the water vapor on the same footing as the other products of combustion, CO^2 and N^2) requires:

$$0.4622 \times 606.5 \text{ (Regnault)} = 280 \text{ Calories.}$$

leaving as the metallurgical or practical calorific power

$$6949 - 280 = 6669 \text{ Calories,} \quad (2)$$

(3) The calorific power of each cubic meter of gas (measured dry at standard conditions) is

$CO = 0.2399 \text{ m}^3 \times 3,062 = 734.6$ Calories.
$CH^4 = 0.0025 \text{ m}^3 \times 8,598 = 21.5$ "
$H^2 = 0.1064 \text{ m}^3 \times 2,613 = 278.0$ "

Total $= 1034.1$ "

Calorific power of gas from 1 kilogram of coal:

$$1034.1 \times 3.43 = 3547.0 \text{ Calories.}$$

$$\text{which equals } \frac{3547.0}{6669.0} = 53.2 \text{ per cent.} \quad (3)$$

(4) The loss of calorific power in conversion is 100 — 53.2 = 46.8 per cent of the calorific power of the coal, or per kilogram of coal:

$$6669 - 3547 = 3122 \text{ Calories.} \quad (4)$$

(5)

Carbon in ashes $= 0.1528 \times 8100 = 1237.7$ Cal.
$= 18.6$ per cent. (5)

(6) The gases produced carry off, per cubic meter measured dry, the following amounts of heat:

Volume $\times$ mean specific heat (0° — 282°) = heat capacity per 1°.

CO^2 $0.0521 \times 0.432 = 0.0225$
CH^4 $0.0025 \times 0.428 = 0.0011$
CO, O^2, H^2, N^2 $0.9454 \times 0.311 = 0.2940$

Sum $= 0.3176$

Heat carried out $= 0.3176 \times 282 = 89.56$ Calories.
Per kilogram of coal $= 89.56 \times 3.43 = 307$ Calories.

$$\text{Proportion of calorific power} = \frac{307}{6669} = 4.6 \text{ per cent.}$$

The above result is, however, subject to a small correction, because some of the moisture in the coal goes undecomposed

into the gases, and is not represented in the analysis of the dried gas. The amount of this moisture can be obtained with sufficient accuracy by finding how much moisture would be obtained by burning the dried gas from 1 kilogram of coal, and comparing this with the moisture which would be obtained from 1 kilogram of coal itself; the difference must represent the moisture accompanying the gas as water vapor, and which has not been included in the above computation.

Burning 1 cubic meter of gas, the H^2O vapor is:

From CH^4	0.0025×2	$= 0.0050$ cubic meters.
From H^2	0.1064×1	$= 0.1064$ " "
		0.1114 " "
Per kilo. of coal	$= 0.1114 \times 3.43$	$= 0.3821$ " "

But the weight of water vapor from burning 1 kilogram of coal has already been found to be (2) 0.4622 kilograms, the volume of which is

$$0.4622 \div 0.81 = 0.5706 \text{ cubic meters.}$$

Leaving, therefore, $0.5706 - 0.3821 = 0.1885$ cubic meters of water vapor as such accompanying the 3.43 cubic meters of (dried) gas from 1 kilogram of coal. This would take out

$$0.1885 \times 0.382 \times 282 = 20.3 \text{ Calories.}$$

Thus increasing the sensible heat in the gases to

$$307 + 20.3 = 327.3 \text{ Calories} = 4.9 \text{ per cent.} \qquad (6)$$

[In reality, a still further correction should be made; viz.: to add in the moisture in the air used, because it would also reappear as moisture on final combustion of the gases. Its amount is found from the amount of air used, which, if 76 per cent saturated at 9° would carry moisture having 0.76×7 mm. (if saturated) $= 5.3$ millimeters tension, which represents, barometer being 712 mm., 0.7 per cent of the volume of the air used, or practically 0.9 per cent of the volume of nitrogen in the air. Since the nitrogen in the gas represents almost entirely the nitrogen in the air used, the moisture to be accounted for from the air amounts to $0.5928 \times 0.009 = 0.0053$ cubic meters per cubic meter of gas, or $= 0.0182$ cubic meters per kilogram of coal burnt. This correction is altogether too small to affect the results in this case, but should be taken into account whenever the air used is warm and moist.]

(7) The calorific loss in conversion was 3122 Calories. Of this we have accounted for:

Lost by unburnt carbon in ashes	1237.7	Calories.
Sensible heat of gases (including moisture)	327.3	"
Total	1565.0	"
Loss by radiation and conduction	= 1557.0	" (a)

Per 8 hours 50 minutes there is burnt 3214 kilograms of fuel, making the loss of heat by radiation and conduction per minute =

$$\frac{1557 \times 3214}{530} = 9.442 \text{ Calories.} \qquad (b)$$

(8) At the conditions given, each cubic meter of moist air used contained 0.7 per cent of its volume of moisture, making its percentage composition by volume:

Water vapor	0.70	per cent.
Air { Oxygen	20.65	"
Air { Nitrogen	79.65	"

The volume of gas produced per kilogram of coal is 3.43 cubic meters, of which 59.28 per cent is nitrogen, equal to 2.0333 cubic meters, and weighing $2.0333 \times 1.26 = 2.562$ kilograms. Of this 0.0050 kilograms came from the coal itself, leaving 2.512 kilograms to come from the air, or $2.512 \div 1.26 = 1.9921$ cubic meters. This would correspond to $1.9921 \div 0.7965 = 2.5011$ cubic meters of moist air if measured at standard conditions. At 9° and 712 mm. pressure the real volume of moist air used at prevailing conditions, per kilogram of coal burnt, is

$$2.5011 \times \frac{273 + 9}{273} \times \frac{760}{712} = 2.76 \text{ cubic meters.} \qquad (8)$$

It must not be thought that the conditions of working in the above producer represent good practice; they are very poor practice as far as concerns the utilization of the fuel. Many producers make gas having 75 to 90 per cent of the calorific power of the coal from which it is made, so that the losses by unburnt carbon and radiation and conduction in this case must be regarded as highly abnormal and very poor practice. The writer chose this example for calculating, because of the carefulness with which Jüptner and Toldt had collected the necessary data, and because it illustrated so well the principles to be employed in similar calculations.

Problem 15.

A gas producer run in Sweden uses saw-dust of the following composition:

Water	27.0	per cent.
Ash	0.5	"
Carbon	37.0	"
Hydrogen	4.4	"
Oxygen	30.6	"
Nitrogen	0.5	"

Assume that it is run by dry air and that 0.5 per cent of ashes are made. The gas formed, dried before analysis, contains, by volume:

Carbon dioxide, CO^2	6.0	per cent.
Carbon monoxide, CO	29.8	"
Ethylene, C^2H^4	0.3	"
Methane, CH^4	6.9	"
Hydrogen, H^2	6.5	"
Nitrogen, N^2	50.5	"

The gas actually produced is partly dried before use by having its temperature reduced by cold water, in a surface condenser, to 29° C., in order to increase its calorific intensity of combustion.

Required:

(1) The proportion of the moisture in the moist gas which is condensed out.

(2) The calorific intensity of the moist gas, if burned preheated to 800° C. by the theoretical quantity of air preheated also to 800° C.

(3) The calorific intensity of the dried gas, burnt under exactly similar conditions.

Solution:

(1) It is first necessary to find the weight or volume of water vapor accompanying the gas before condensation, next that accompanying it after passing the condenser. The first can be calculated best on the basis of the hydrogen present in the fuel and in the (dried) gas made from it; the difference is the hydrogen of the moisture removed before analysis, *i. e.*, the hydrogen of the moisture in the wet gas.

The first step is to find the volume of gas (dry) produced per unit of fuel, as follows:

Carbon in 1 kilo. of fuel $= 0.370$ kilos.

Carbon in 1 m^3 of gas $= CO^2 + CO + CH^4 + 2C^2H^4$ $(0.060 + 0.298 + 0.069 + 0.006) \times 0.54$ $= 0.2338$ "

$$\text{Dry gas per kilo. of fuel} = \frac{0.370}{0.2338} = 1.5825 \text{ m}^3$$

The next step is to calculate the water which would be formed by the combustion of 1 kilogram of fuel:

Water present in fuel	0.270	kilos.
Water produced by hydrogen	0.396	"
Total =	0.666	"

$$\text{Volume at standard conditions} = \frac{0.666}{0.810} = 0.8222 \text{ m}^3$$

From this we subtract the moisture which would be produced by the combustion of the 1.5825 cubic meters of dry gas, obtained as follows:

Water from ethylene $= 0.003 \times 2 \times 1.5825 \text{ m}^3$
Water from methane $= 0.069 \times 2 \times 1.5825$
Water from hydrogen $= 0.065 \times 1 \times 1.5825$

$= 0.209 \quad \times 1.5825 = 0.3307 \text{ m}^3$

Difference = water vapor to 1.5825 m³ of dried gas
$= 0.8222 - 0.3307 = 0.4915 \text{ m}^3$
$= 0.4915 \div 1.5825 = 0.3106 \text{ m}^3$ per 1 m³
of dried gas, as analyzed.

This is to be compared with the amount of moisture accompanying the same quantity of (dried) gas as it escapes from the condenser. This is obtained directly from the fact that the gas escaping will be saturated with moisture at 29° C., that the latter will, therefore, have a tension of 30 millimeters (tables), and that, assuming the barometer normal (760 mm.), the partial tensions of moisture and gas proper are as 30 to 760 — 30, or as 30 to 730. Since their respective volumes (if both were measured separately at normal pressures) are in the same proportion, it follows that each cubic meter of (dry) gas is accompanied by $30 \div 730 = 0.0411$ cubic meters of uncondensed moisture.

The respective quantities of moisture accompanying 1 cubic meter of dry, uncondensable gas, are, therefore, 0.3106 before cooling and 0.0411 after cooling, showing that 13.5 per cent of all the moisture escapes condensation, and that, therefore,

86.5 per cent of moisture is condensed. **(1)**

(2) The wet gas has a calorific power, calculating on the basis of 1 cubic meter of dried gas analyzed:

CO	$0.298 \times 3{,}062 =$	912.5	Calories.
C^2H^4	$0.003 \times 14{,}480 =$	43.4	"
CH^4	$0.069 \times 8{,}598 =$	593.3	"
H^2	$0.065 \times 2{,}613 =$	169.8	"
	Total =	1719.0	"

There is added to this available heat, when burned, the sensible heat in the gas itself, at 800° C., and also that of the necessary air, also at 800°.

Heat in gas:

$CO,H^2,N^2 = 0.630 \text{ m}^3 \times 0.3246 = 0.2045$ Cals. per 1°
$CO^2 = 0.060 \text{ m}^3 \times 0.5460 = 0.0328$ "
$CH^4 = 0.069 \text{ m}^3 \times 0.4485 = 0.0309$ "
$C^2H^4 = 0.003 \text{ m}^3 \times 0.50 = 0.0015$ "
$H^2O = 0.3106 \text{ m}^3 \times 0.460 = 0.1429$ "

Calorific Capacity = 0.4126 "

Total sensible heat $= 0.4126 \times 800 = 300.1$ Calories.

The air required theoretically is:

For CO $0.298 \text{ m}^3 = 0.1490 \text{ m}^3$ oxygen
For C^2H^4 $0.003 \text{ m}^3 = 0.0090 \text{ m}^3$ "
For CH^4 $0.069 \text{ m}^3 = 0.1380 \text{ m}^3$ "
For H^2 $0.065 \text{ m}^3 = 0.0325 \text{ m}^3$ "

Sum $= 0.3285 \text{ m}^3$ "
$= 1.58 \text{ m}^3$ air

Heat in this at 800° $= 1.58 \times 0.3246 \times 800 = 410.3$ Cals.

Sum total of heat going into the products:

Developed by combustion...........	1719.0 Cals.
Sensible heat in gas.................	330.4 "
Sensible heat in air.................	410.3 "
Total	2459.4 "

The products of the combustion are CO^2, H^2O and N^2, as follows: $CO^2 = 0.060$ (in gas) + 0.298 (from CO) + 0.006 (from C^2H^4) + 0.069 (from CH^4) = 0.433 m³.

$H^2O = 0.311$ (with gas) + 0.006 (from C^2H^4) + 0.138 (from CH^4) + 0.065 (from H^2) = 0.520 m³.

$N^2 = 0.505$ (in gas) + [1.58 — 0.33 = 1.25] (from air) = 1.755 m³.

Since the 2459.4 Calories remains as sensible heat in the above products, at some temperature t, we have:

Heat capacity of the CO^2 $= 0.433\,(0.37 + 0.00022t)$
Heat capacity of the H^2O $= 0.520\,(0.34 + 0.00015t)$
Heat capacity of the N^2 $= 1.755\,(0.303 + 0.000027t)$

Heat capacity of the products $= 0.8688 + 0.00022065t$

and the calorific intensity t must be

$$t = \frac{2459.4}{0.8688 + 0.00022065t}$$

whence

$$t = 1907^\circ \qquad (2)$$

(3) When the dried gas is burned under similar conditions, the only difference is that 0.2695 m³ of water vapor are absent from the gas and from the products, having been condensed. This reduces the available heat by the sensible heat in this much water vapor at 800°, viz.:

$$0.2695 \times 0.460 \times 800 = 99.2 \text{ Calories,}$$

and decreases the calorific capacity of the products by

$$0.2695\,(0.34 + 0.00015t).$$

Our equation, therefore, becomes

$$t = \frac{2360.2}{0.7772 + 0.00018023t}$$

whence

$$t = 2056^\circ \qquad (3)$$

The increased efficiency of the dried gas for obtaining high temperatures is too evident to need further comment, the difference being in round numbers 150° C. (= 270° F.) in favor of the dried gas.

Welding With Thermit.

In the meeting of Oct. 18 of the Franklin Institute of Philadelphia, Mr. Ernest Stütz, general manager of the Goldschmidt Thermit Co., presented a paper on recent developments of the thermit process in American practice. Since our readers are well acquainted with the process[1] our report will be restricted to new information, of which much is found in Mr. Stütz's paper.

Rail Welding.—The thermit welding process of obtaining a continuous rail for electric street railways has been applied during a little more than the last year in about thirty cities in the United States, and 13,000 joints have been welded; among these, 3000 in Cleveland, Ohio, and 1000 in Holyoke, Mass. In both cases the street railway companies trained their own men in the application of the process. They trained their "gangs" of four men, who, in the course of a day, made about thirty joints. They made and dried their own molds. In New York City, some 300 to 400 joints have just been completed on parts of Grand Street.

Repairs by Thermit.—The advantages of this application of thermit are seen in the problem of repairing broken locomotive frames. In this case the operation is performed with the aid of thermit without dismantling the engine, and at a cost of about $50, and the time required is two days, while previously such frames could only be repaired by dismantling the engine, and at a cost of $250 to $300, the time required being two weeks.

[1] See the papers of Dr. Hans Goldschmidt in our vol. 1, page 527; vol. 2, pages 145, 405; vol. 3, pages 168 and 226.

The principle guiding the construction of the mold is that the thermit steel must not impinge directly on the casting to be repaired, but must run into the gate below the lowest point and be made to rise from there, through and around the fracture, enclosing the latter with a strong collar, which fuses with the material of the frame. The first steel running out of the crucible into the mold, however, becomes chilled when coming in contact with the casting, which, even when preheated, has a considerably lower temperature than the thermit steel. This chilling effect can only be overcome by a sufficiently large supply of thermit steel, so that the cooler part of the liquid mass is driven up into the riser and is replaced in the collar surrounding the frame, by metal which has practically the full temperature it received during the reaction.

The important point in making welds by thermit is to obtain a good circulation of the thermit steel, around and through the piece to be repaired, and the rule is given, that to ensure a really good weld, the quantity of thermit should be twice that which would be sufficient to fill the actual collar which is to be welded on. The main requirements for successful welds are the use of a sufficient quantity of thermit; design of the mold so as to provide sufficient vent for the air; the mold must be sufficiently porous and sufficiently dry.

If sharp sand and ordinary brickmakers' clay are used for molding material, they must be mixed in equal parts and must be burnt dry. To only skin-dry such molds means metal full of blow-holes, as the moisture at the back of the molds is sure to turn into steam and force its way out into the liquid steel.

For small operations, satisfactory results have been obtained by mixing ten parts of coarse sand with one part (by volume) so-called, of "no-grade" flour. These molds cannot be burnt dry, as they would go to pieces, but through the action of the steel the flour gets burnt together with the sand and carbonizes to such an extent as to protect the back parts of the mold. With molds made in such a manner, perfectly sound pours have been made in street railway work.

Wherever available, firebrick, cut down to size and carefully luted, offers a very convenient material for molds. They do not require hard drying, although even such a mold ought to be warm before being used.

A very important application of the process is in marine engineering. The author described at some length the process of a repair made on the Clyde line steamer "Apache."

An improved method of making such welds has lately been developed at the Essen works of the Goldschmidt Co. The mold is placed in position after the fracture has been opened out and cleaned, but before it is heated. A suitable coke stove is then placed over the mold and connected with it is a blower, which drives the fire gases through the coke, around the piece to be welded, and brings not only the latter but also the mold to a high state of temperature, thus facilitating the weld and eliminating all possibility of moisture in the mold. This process has been found particularly valuable for the repair of pieces of great diameter.

Thermit in Foundries.—Most defects in castings are naturally detected before they leave the foundries, and for this reason steel foundries were among the first to appreciate the great value of the thermit process, since it enabled them to save a large number of castings.

The author described some noteworthy repairs of gray-iron castings, especially the method applied in the repair of the spoke of a 14-foot fly-wheel at the works of C. M. Robertson & Co., in Montville, Conn. Work with gray-iron castings requires more experience in regard to preheating and cooling down gradually. More thermit is necessary to effect the weld in this case, on account of the hard, glassy scale on such castings, which resists fusion, and an addition of ferrosilicon (about 2 per cent) is advisable, to prevent hard spots at the line of junction between the thermit steel and the cast iron.

Some of the smaller defects have even been repaired without the use of a crucible, by placing a "pouring cup" over the defect and igniting the thermit directly in this cup. The cup, of course, must be absolutely dry and must be carefully luted from the outside.

Many foundries have adopted the use of thermit for reviving dull iron in the ladle and keeping open the risers (see our Vol. I., p. 533, and Vol. II., p. 405). Where there is a question of obtaining particularly dense castings, such as are used for cylinders and valves, a special thermit is recommended, which contains a slight addition of titanium. (Concerning the use of nickel thermit and titanium thermit see p. 251 of our Vol. III.)

Pipe Welding.—The first application of the thermit process for pipe welding has recently been made in New York City for the Manhattan Refrigerating Co. The pipes were laid in the ground on Fourteenth Street, and are used as service return pipes in the delivery of liquid ammonia—180 pounds pressure—to various cold storage houses along the street. Twenty-nine 1¼-inch and twenty-seven 2-inch joints were welded. The pipe was welded on the ground, to lengths varying from 40 to 100 feet, then placed into the ditch, cuts made for connections, and the final welding done with the pipe in place. On the 2-inch line an expansion bend was placed, while on the 1¼ inch this was not thought necessary. Both lines were tested out before being thrown into service, and no failures showed themselves.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

ELECTROLYSIS.

Purification of Metals.—H. M. Chance, 800,984, Oct. 3. Application filed June 2, 1905.

The metal is freed from impurities by means of reagents, which have a higher affinity for the impurities than for the metal. So far the method is exactly the same as the usual purification of metals by means of a suitable slag. But in the present case the reagent is applied in the "nascent state," being set free at the fused metal (which forms one electrode) from an electrolyte containing the purifying reagent as an ion. For instance, the fused metal may be made cathode, and as electrolyte may be used the salt of an alkali or alkaline-earth metal, not volatile at the temperature used. In this way iron and steel may be purified by contact with fused calcium chloride as electrolyte. Here calcium is set free at the surface of the metal and then serves as the purifying reagent. If a metal is to be freed from easily-oxidizable impurities, it is made anode, and an electrolyte is used which yields oxygen at the anode.

Electrolytic Production of Metallic Sodium.—E. A. Ashcroft, 801,199, Oct. 10. Application filed Oct. 3, 1903.

The inventor uses a cell, which is in principle like the Castner-Kellner; but on account of the employment of

fused salts, he cannot use mercury, and employs, therefore, fused lead like Acker. The Ashcroft cell is shown in Fig. 1. At the bottom of the whole cell is the fused lead F. The central compartment A contains fused sodium chloride as electrolyte above the fused lead. D is the carbon anode; it is grooved to provide a large surface. C is the outlet for the chlorine gas set free at the anode, B the salt feed. The sodium which is set free at the surface of the lead (which here acts as cathode) alloys with the lead. By means of the electromagnet G, set in the iron pot G^1 to close the magnetic circuit, the contents of the cell are forced to whirl more or less violently, so that the sodium-lead alloy is brought from the central inner compartment into the annular outer department. Here the sodium-lead alloy forms the anode; the electrolyte J is fused caustic soda. The cathodes L are of nickel or iron. The electrolytic action in this outer compartment is that sodium passes from the sodium-lead alloy into the electrolyte, and metallic sodium is obtained at the cathode. The electrolyte in this outer compartment is, therefore, not consumed. The only material that is consumed in the whole cell is the sodium chloride fed through B into the central compartment. The end products are chlorine, set free at the anode in the central compartment, and metallic sodium set free at the cathode in the outer compartment. The temperature of the NaCl in the central compartment is maintained at 750° to 850° C., the temperature of NaOH in the outer compartment is 300° to 350° C.

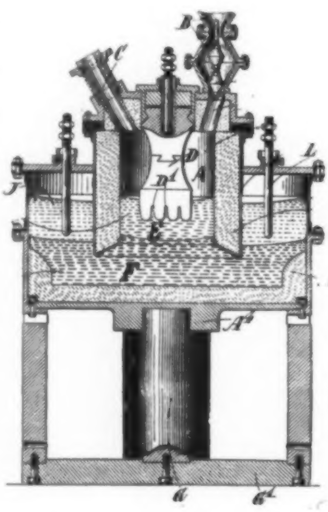


FIG. 1.—ELECTROLYTIC PRODUCTION OF SODIUM.

Producing Chlorates and Bichromates.—A. E. Gibbs, 802,-205, Oct. 17. Application filed March 1, 1904.

Chlorate and bichromate are simultaneously produced by means of the reaction, $6Na_2CrO_4 + 6Cl = 3Na_2Cr_2O_7 + 5NaCl + NaClO_3$. A stream of chlorine gas is passed through a chromate solution at 70° to 80° C., and the products of the reaction are bichromate, chlorate and chloride. They may be separated by crystallizing, etc. In this form the process is applicable in plants which produce chlorine by electrolysis of common salt, and do not wish to work up the whole output of chlorine into bleaching powder. It is, however, possible to obtain the above reaction by direct electrolysis in a cell, the chlorine being in this case obtained by electrolytic decomposition of chloride in the cell which also contains chromate. The inventors mention two possible arrangements, the cell being in both cases divided into two compartments by a porous diaphragm of asbestos, etc., and the anode and cathode being of platinum or iron respectively. Either both compartments are filled with a mixture of chromate and chloride or the chloride solution is put into the cathode compartment and the chromate solution into the anode compartment. If it is desired to increase the proportion of chlorate relatively to the bichromate in the resulting solution, the inventor adds from time to time to the anode compartment some alkali, to produce the reaction,

$$Na_2Cr_2O_7 + Na_2O = 2Na_2CrO_4$$

Reducing Metals and Making Alloys.—H. S. Blackmore, 802,153, Oct. 17. Application filed Aug. 22, 1904; Jan. 6, 1905.

To produce an alloy of two metals from their oxides, a mixture of the oxides is dissolved and electrolyzed in a solvent of molten oxides of such metals as have greater affinity for oxygen than the metals which shall form the alloy. For instance, for the production of aluminium alloys the solvent is a mixture of lithium oxide and calcium oxide in proportion of four to one. This mixture is fused by an alternating current. If the object is to produce an alloy of aluminium with copper, copper aluminate or copper oxide with aluminium oxide is added to the molten bath of calcium and lithium oxides and readily dissolves. On electrolysis with direct current a copper aluminium alloy is obtained. The alternating current for keeping the mass in a molten state is passed through the cell in a path which is at an angle to the path of the direct current for the metal deposition.

ELECTRIC FURNACES.

Induction Furnace.—F. A. Kjellin, 800,857, Oct. 3. Application filed July 6, 1905.

The object is to protect the primary winding of an electric induction furnace from the heat of the furnace chamber. The construction is shown in Fig. 2; a is the brickwork, b the annular furnace chamber, c a central opening in the brickwork, d the laminated iron core forming the closed magnetic circuit, and e the primary winding to which the electrical energy is supplied. In the central opening c between furnace chamber b and induction coil c there are placed one or more concentric double-walled casings, or jackets f of sheet iron; they do not form a closed ring, but are divided at one or more places by electric insulating material g, to prevent the production of inductive currents in the jacket. On both sides of the interruption g the inlets h and outlets h′ for the cooling medium (air or water) are provided, so that it may be circulated through the jacket.

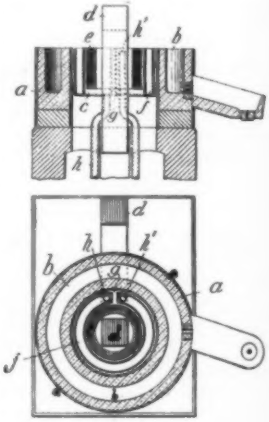


FIG. 2.—ELECTRIC INDUCTION FURNACE.

Production of Molded Blocks, Tubes, etc., of Carborundum.—F. Bölling, 801,296, Oct. 10. Application filed March 14.

A body of the desired form is first made of pure carbon and then embedded in finely powdered silicon carbide (or boron carbide). By means of a "firing" process the body (or its surface) is converted into silicon carbide by "absorption." To prepare tubes of silicon carbide, a solid carbon cylinder is treated in the manner described, whereby an outer layer of silicon carbide is formed, and an inner core of carbon remains present, and is afterwards burnt out by keeping the tube at a red heat; the outer layer of carbide remains, since it is almost incombustible.

Containers for Acids and Chemicals from Fused Quartz.—Edward Hart (assigned to General Chemical Co.), 801,378, Oct. 10. Application filed Dec. 4, 1902.

A mold A (of carbon or "metal-lined with graphite") is formed of the desired shape and connected by the conductor B with one pole of the source of electric current. A

small quantity of crushed quartz or highly-silicious sand D is placed in the center of the mold, and an arc is started between the mold A and the electrode C, whereby the quartz particles become pasty or plastic, indicating an incipient fusion. When the central part of the article has thus been formed, more crushed quartz is added around it and treated in the heat of the arc, and the article is thus gradually built up. If the mold is made of non-conducting material, two electrodes must be used above it, and both moved together relatively to the mold. "When using highly-silicious material, the resulting articles present a glazed surface, and are not very strong, but are little liable to attack by acids and are wholly refractory. They cannot only stand high temperatures, but their coefficient of expansion is so small that an article of this character may be heated to a very high temperature and immediately plunged into cold water without suffering any injury.

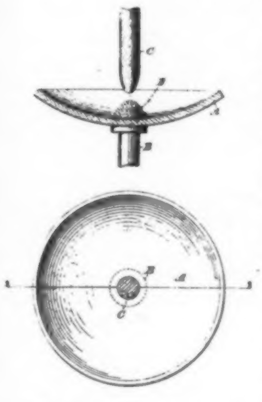


FIG. 3.—MANUFACTURE OF VESSELS OF FUSED QUARTZ.

Batteries.

Grid for Lead Accumulators.—W. Gardiner, 800,638, Oct. 3. Application filed June 11, 1904.

Claim 1 reads: "A storage-battery plate, comprising a lead grid having cross-pieces, each formed with longitudinally-extending top and bottom offsets facing in opposite directions, and suitable material to become active held in recesses formed between the said cross-pieces, the top and bottom surfaces of said cross-pieces extending horizontally from one face of the plate to the other, the said offset surfaces being vertical and at right angles to said horizontal surfaces, said horizontal portions of the grid having comparatively thin and straight unbroken outer edges, whereby the opposite surfaces of the plate, when in use, present a maximum of active surface and a minimum of inactive surface."

Zinc Accumulator.—C. B. Askew, 800,619, Oct. 3. Application filed Aug. 24, 1903.

In a "zincate" cell (with zinc as one electrode and an oxide, like copper oxide, as other electrode) there is a difficulty during charging, due to the deposition of the zinc in non-coherent form. Zinc, therefore, drops to the bottom of the cell, and when it has accumulated sufficiently there will be a short circuit. To prevent such an accumulation, the inventor divides the space between two vertical oxide electrodes into a series of transverse compartments, one above the other; curved troughs of insulating material extending transversely from one oxide plate to the next one. If any zinc drops off from the zinc plate (midway between the two oxide plates), it cannot drop down to the bottom of the cell, but only to the next trough below. This is so shaped that no contact between the zinc with the oxide plates is possible.

Miscellaneous.

Purifying Water.—J. F. Lester, 799,605, Sept. 12. Application filed Nov. 28, 1904.

Details of an apparatus combining electrolytic treatment of water with sterilization by ozone and with filtering. The water enters at the bottom of the apparatus into the receiving chamber, where the larger foreign particles settle down. This receiving chamber is closed at the top by a porous partition, through which the water passes upwards into the electrolytic chamber, containing electrodes which also act as baffle-plates, forcing the water to assume a zig-zag course. Next above the electrolytic chamber comes the ozonizing chamber. Above this is another chamber in which the ozone continues to act on the water. Now, the water passes downwards again through a filtering medium to remove the "milky scum" produced by the action of the electrical energy. The apparatus is cleaned from time to time by forcing water into the various chambers through a system of pipes.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

Industrial Electrochemistry in Europe.

Exposition at Liege.—The electrochemical and electrometallurgical exhibits at the International Exposition in Liege are the subject of an interesting report by Maurice Laneau, a member of the Jury, in the "Bulletin Mensuel" of the Société Belge d'Electriciens. This paper is to some extent representative of the present condition of the electrochemical and electrometallurgical industries in Europe, or, at least, in France and Belgium. The following abstract will be mainly restricted to those portions of Mr. Laneau's report which contain new information.

Electrometallurgy of Iron and Steel.—The exhibits of chief interest were those of the French and Swedish companies making ferroalloys and special steels in the electric furnace. Keller, Leleux & Co. have two plants, one of 600 hp., at Kerrousse (Morbihan), the other of 15,000 hp., at Livet (Isère); they make 250 tons of ferrosilicon per month, the percentage of Si ranging between 25 and 75 per cent. They also make 150 tons of silicospiegel per month. "The manufacture of alloys rich in Mn 38 to 40 per cent, and Si 22 to 24 per cent, consists in treating a fused charge of ferrosilicon, silica, carbon and manganese ore." The company also produces 80 tons of ferrochrome monthly and occasionally ferrotungsten. A model of Keller's furnace for the reduction of pig iron is exhibited; it is the same which was described and illustrated in our Vol. II., p. 483, Figs. 1 to 3. Keller's steel furnace is similar to that of Héroult. "An important steel works, the firm of J. Holzer, in Unieux, is at present installing an electric furnace of this type for refining open-hearth steel. It will permit the production of 8-ton ingots for the manufacture of guns of large calibre."

The Société Electrométallurgique Française, which operates under the Héroult patents, has a 13,000-hp. plant at La Praz (Savoie), a 6,000-hp. plant at St. Michel-de-Maurienne (Savoie), and a plant at Gardanne (Bouches du Rhône). They produce aluminium, ferrochrome, ferrosilicon and other ferroalloys, and 3,000 tons of tool steels per year. Concerning the Héroult steel process see our

Vol. I., pp. 63, 287, 449, 467; Vol. II., pp. 408, 481; Vol. III., pp. 45, 155, 337.

The Société Anonyme Electrométallurgique, Procédés P. Girod, has two plants, one of 4,000 hp., at Courtepin (Switzerland), and the other of 8,100 hp. at Ugine (Savoie). The company is said to be the largest producer of ferrotungsten in the world. "This company also studies the production of steel, and has made for several years continued industrial tests, and the reason why it has not yet entered this field on a commercial scale is because it does not wish to compete with its customers for ferroalloys." Fig. 1 shows the Girod furnace, the upper diagram being a vertical section along the line AB in the lower diagram. It comprises a containing vessel of magnesia brick and has a cover of silica brick, through which pass several electrodes, all of which are connected to one pole of the supply circuit. From there the alternating current passes through the bath to the lower electrodes, which are embedded in the brick work, and consist of water-cooled pieces of cast iron. There are fourteen such lower electrodes for a furnace of 2 meters diameter, and each of them is in contact with a canal reaching up to the crucible and filled with extra soft iron before the furnace run begins. The furnace is placed on a cradle to facilitate operation. The charge consists of scrap mixed with a small amount of good cast iron. The upper electrodes are suspended in the slag, which is made up from the very pure ores of the Pyrenees and from Batère hematite. The decarburization is pushed as far as possible, and the steel is afterwards recarburized. In the 250-kw. furnace, which has been in actual operation, 1.5-ton charges are treated, 1 ton taking about 4½ hours. Concerning the cost per ton of steel, the following figures are given:

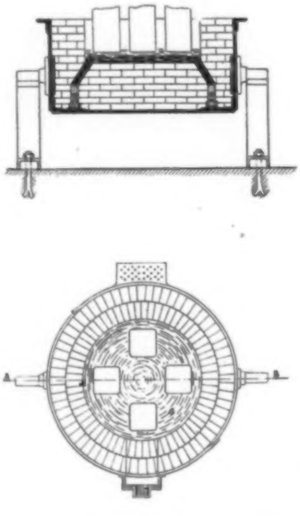


FIG. 1.—OSCILLATING STEEL FURNACE OF GIROD.

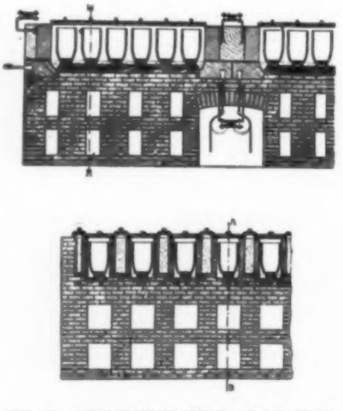


FIG. 2.—RESISTANCE FURNACE OF GIROD.

Energy (1,060 kw-hours at 0.5 cent)....	$5.30
Electrodes (10 kg.)....................	0.20
Maintenance of furnace................	1.60

Girod has also made experiments with electric resistance furnaces in which crucibles are heated by means of resistors from the outside. (See also our Vol. II., p. 309, Figs. 1 and 2.) The crucibles are placed in retorts between which the resistor material is heaped up (evidently in crushed form), consisting of carbon and silica. The nature of the material which forms the walls of the retorts permits a temperature up to 1400° or 1500° C. (while with alumina brick temperatures of 1600° to 1700° C. can be obtained). The construction of the furnace is shown in Fig. 2, the upper diagram being a section through line AB, the lower diagram through line MN.

To obtain higher temperatures Girod has devised the arrangement shown in Fig. 3. He places resistances on the bottom of the retort. On account of the restricted section of these resistances, obtained by the insertion of "fromages" 3, which support the crucibles, the temperature may be brought up to 2000° C. In order to protect the bottom and the sides of the retort, two zones of different mixtures of resisting material 1 and 2 are provided in such a way that the central portion conducts the greatest part of the current. A higher potential difference is applied at the terminals of these resistors than at those of the others. It is stated that the temperature can easily be adjusted by 50° or 60° up to 2000° or 2500° C., by varying the impressed e. m. f., the connections between the resistors and the pressure on the resistors. From tests made in a 25-kw. furnace, the cost of steel per ton is given as $4.60 (being the sum of cost of power, 1440 kw-hours, $2.28; crucibles, $1; maintenance, labor and amortization, $1.30).

G. Gin exhibits models of two types of steel furnaces. His first type was described in our Vol. II., p. 20, and Vol. III., p. 297; it is characterized by a long, narrow channel filled with the charge (somewhat like an incandescent lamp filament on a very large scale). A furnace of this type is stated to be in operation in Plattenberg, Germany, since Jan., 1905, but nothing is yet known concerning the economical results. The second type of furnace, exhibited by Gin in form of a model, was described on page 372 of our October issue.

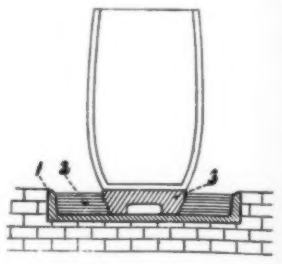


FIG. 3.—DETAILS OF GIROD RESISTANCE FURNACE.

The Metallurgiska Patentaktiebolaget, of Stockholm, Sweden, produces annually in the Kjellin induction furnace about 1500 tons of high-grade steels (this is about 1½ per cent of the total production of steel in Sweden). Concerning the Kjellin furnace, see our Vol. I., pp. 141, 283, 376, 562, 526, 546; Vol. II., p. 479; Vol. III., pp. 134, 299, 341, and a patent of Kjellin in the Analysis of Current Electrochemical Patents in our present issue.

Electrolysis of Water.—L'Oxhydrique Société Anonyme of Brussels, Belgium, makes regular demonstrations at the Exhibition on welding with the oxyhydrogen flame. This company uses the electrolyzer of Garuti for the production of oxygen and hydrogen gas from water. One of the latest applications—which, however, seems to be still in the experimental stage—is the cutting of iron sheets by a stream of oxygen. The Garuti electrolyzer was noticed in our Vol. I., p. 463. Both caustic potash and caustic soda are used as electrolytes; caustic potash has the advantage of smaller resistivity, and consequently of smaller power consumption; caustic soda has the advantage of lower cost.

Electrolysis of Sodium Chloride; Mercury Cathode.—A special pavillion in the Exhibition contains the exhibits of the Société Solvay et Cie, of Brussels, Belgium. This company has studied since 1895 the electrolysis of sodium chloride, the starting point being the patents of Castner and Kellner. The Solvay company has developed its own mercury cathode cell, the advantages of which are said to

be large units and small attendance required. The Solvay cell is shown in Fig. 4. The arrangement of the carbon anodes is shown in the lower diagram. The cathode is formed of mercury covering the bottom of the cell. The mercury enters through pipe B; the amalgam, which is lighter than the mercury, flows over at C, and is taken out of the cell through tube D. The amalgam is then treated

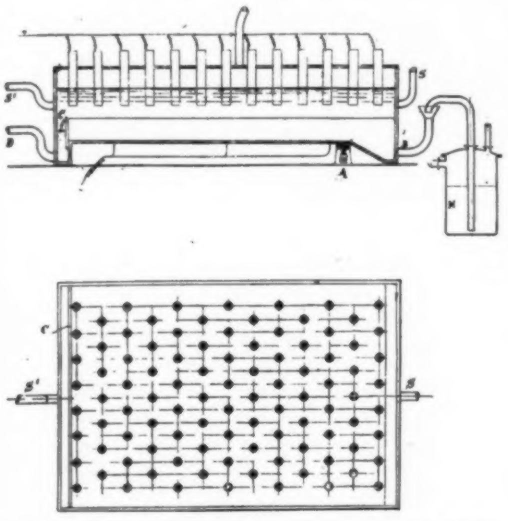


FIG. 4.—SOLVAY CELL FOR ELECTROLYSIS OF SODIUM CHLORIDE.

outside of the cell to obtain sodium hydroxide, and the regenerated mercury is returned into the cell through M and B. (It will thus be seen that the mercury acts in this cell as cathode pure and simple, and does not act as a bipolar electrode.) The sodium chloride solution enters

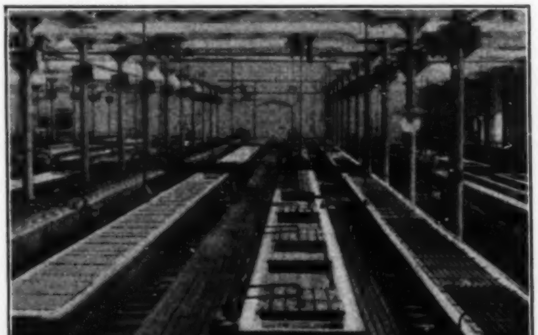


FIG. 5.—CELL ROOM OF JEMEPPE WORKS OF SOLVAY CO.

the cell through S', and leaves through S, the direction of its flow being, therefore, opposite to that of the mercury. The 1000-hp. plant at Jemeppe-sur-Sambre, the cell room of which is shown in Fig. 5, produces in the whole 7500 tons of various products per year; caustic soda, caustic potash and bleaching powder. The caustic soda is of high purity, containing 98.95 per cent of NaOH and only 0.09 per cent of NaCl. (The caustic soda of the Castner-Kellner Electrolytic Alkali Co., of Niagara Falls, contains 99.5 per cent NaOH.)

Chlorates, Sodium Peroxide, etc.—The Société d'Electrochemie has two plants at St. Michel de Maurienne and at Vallorbe. The principal products are potassium and sodium chlorates, of which 13,000 to 15,000 are made per year by the Gall and Montlaur process. They also make annually over 200 tons of peroxide of sodium; this is made by passing a current of air over metallic sodium enclosed in an electrically-heated platinum tube. "Sodium peroxide is highly praised for bleaching of linen and wool; by dissolving it in acidulated water in the desired proportions, one gets oxygenated water." "By compressing the dioxide with copper salt, a product is obtained called oxylithe, which serves for the evolution of oxygen by simply immersing it in water. Oxygenated water and sodium hydroxide are thereby formed. The latter, by reacting with the copper salt, gives a hydrate which determines the decomposition of the oxygenated water formed, thus resulting in the evolution of oxygen." Since the demand for sodium peroxide has somewhat decreased, the company uses part of it for the manufacture of barium peroxide by a process which is not described.

The Société Anonyme des Forces Motrices et Usines de l'Arve, with a 13,000-hp. plant at Chedde (Haute-Savoie), produces 4000 tons of chlorates per year.

Electroplating.—Prof. Classen, of Aix-la-Chapelle, exhibits electrolytic zinc deposits which are perfectly bright when taken from the bath. "In order to give an idea of the appearance of the deposit, we may compare the articles galvanized by his process with tinned articles." The process is not described. The brightness of the deposit is considered to be an indication of its good quality.

Copper tubes made by the Elmore process are exhibited by the Société Française d'Electrométallurgie, which operates this process since 1891 at Dives-sur-Mer (Calvados). The rôle of the agate burnishers is apparently not yet definitely fixed; at Dives the pebble-stones of agate are fixed in their chapes and operate by friction, while in the German plant at Schladern they are mounted on the axles and operate by simple pressure.

Electrolytic Refining Plant.—The Russian refinery of J. K. Nicolaeff, in Moscow, produces per year 2500 tons of different products (500 tons electrolytic copper, 200 tons bronzes, 800 tons alloys, 320 tons of tubes and other articles of lead, 320 tons copper sulphate, 240 tons iron sulphate, 1 ton silver, 0.04 gold, etc.) of a total value of $1,000,000.

Detinning.—In the detinning section of this plant the current is furnished by a 12-kw. generator, giving 600 amps. The tinned iron scrap is placed in iron caskets forming the anode. The electrolyte is a solution of NaOH. Under the action of the current the tin oxidizes, and metastannate forms; the tin is deposited in spongy form on the leaves of metallic copper, which form the cathodes. After a certain time, the solution absorbs CO_2 from the atmosphere and contains impurities, due to the saponification of the varnish, rust and sodium ferrates. "The solution is regenerated in iron vessels by a stream of Co_2, which precipitates the SnO_2 of the metastannate and transforms the electrolyte into a mixture of alkaline carbonate with the impurities mentioned above. They are eliminated, and the solution is regenerated by means of quick lime and heating."

Copper Refining.—This part of the plant contains 240 refining cells, the current being furnished by four generators, giving 25 by 500, 10 by 480, 20 by 400, and 25 by 300-volt amperes, respectively. The first of these supplies the cells, in which the current density is 0.5 amps. per square decimeter, and in which anodes containing 90 to 95 per cent of copper are refined. For the refining of anodes containing 76 to 85 per cent of copper a current density is used not

over 0.2 or 0.3 amp. per square decimeter. The electrolyte contains 10 to 15 per cent of copper sulphate and 6 per cent free sulphuric acid.

Batteries.—A. Wedekind exhibits a cell of the Lalande type, with zinc and copper oxide as electrodes and potassium hydroxide as electrolyte. When discharged, the copper plate is reoxidized by heat, while the zinc and the electrolyte must be replaced. Other primary cells are exhibited by the Maison Leclanche et Cie, of Paris, and the Maison Delafor, of Paris. Among the numerous storage batteries exhibited by Belgian and French companies are the well-known Tudor accumulator and the chloride cell of the Société pour le Travail Electrique des Metaux, of Paris (which is affiliated with the Electric Storage Battery Co. of this country).

Industrial Electrochemistry.

Chlorate Analysis in Electrolytic Chlorate Manufacture.—In the "Chemiker-Zeitung," Vol. XXIX., No. 18, M. Couleru remarks that a few years ago the ampere-hour efficiency of electrolytic chlorate manufacture was about 60 per cent and the watt-hour efficiency 30 per cent, while with improved modern methods an ampere-hour efficiency of 90 per cent and a watt-hour efficiency of 65 per cent is obtained. For chlorate analysis ordinary direct chemical methods may, of course, be applied, but indirect physico-chemical methods are in some respects more convenient. These methods are based on gas analysis. Electrolysis of water yields hydrogen and oxygen in the volume proportions of 2 to 1. In the present case the oxygen is consumed for oxidation of chloride, that is, for the formation of chlorate. A theoretical ampere-hour efficiency of 100 per cent would correspond to pure hydrogen. Any impurities in the hydrogen (consisting mainly of oxygen and traces of chlorine and chlorine products) indicate a decreased ampere-hour efficiency. The amount of oxygen mixed with the hydrogen will, therefore, be a measure of the actual ampere-hour efficiency. If the latter is 0, 50, 100 per cent, the hydrogen contains 33.3, 20, 0 per cent of oxygen, respectively. Since hydrogen is sixteen times lighter than oxygen, small quantities of oxygen are easily found by weighing. Any balance which indicates 1 or 2 milligrams is suitable for this purpose. On one scale a reversed Erlenmeyer flask is suspended, a thin glass tube passing upwards into the upper part of the same. The balance is adjusted for pure hydrogen passing through. As soon as a gas heavier than pure hydrogen passes through, the balance will tip, and the weight required to readjust the balance will indicate the amount of oxygen in the gas and the corresponding ampere-hour efficiency. A balance may thus be empirically calibrated by passing different mixtures of gas through. This simple and cheap method is said to be sufficient for many purposes. For larger experiments and for continuous records the gas balance of Lux is recommended. It is thus possible to find at any time the current efficiency directly. If an exact recording voltmeter is also available it is possible to follow accurately the electrolytic operation and to find at once when something is wrong. Some tables are given, and it is pointed out that some precautions are necessary in the use of this method, since the composition of the electrolytic gas depends on various factors. If, for instance, the temperature in the electrolyte decreases, the content of hypochlorite increases and the oxygen gas is consumed for production of hypochlorite. The same is the case at the beginning of electrolysis if fresh chloride solutions are used. For skilled experts in chlorate manufacture, however, the method is highly recommended and considered to be very convenient.

Hypochlorite for Disinfecting Purposes.—The issue of Sept. 22 of the London "Electrician" contains an abstract of a report by Dr. F. W. Alexander, "medical officer of health" to the Metropolitan Borough of Poplar. It is entitled "Upon the Manufacture of Electrolyzed Salt Water (Chloride of Sodium and Chloride of Magnesium) for Disinfecting Purposes." He recommends the distribution of the hypochlorite solution throughout the borough for deodorizing and disinfecting purposes. The chemical explanation of the electrolytic production of hypochlorite, as given in the report, is slightly amusing.

Dry Cell.—For the electrification of electromotor needles and similar purposes a dry cell with constant e. m. f. is useful. J. Brown describes in "Lond. Elec." of Sept. 15, tests of such a pile constructed on Daniell's principle. Sheets of commercial zinc and copper, 9 inches square, were coated on one side with sheets of twilled cotton fabric (as used for glass cloths), wet with hot 10 per cent solutions respectively of zinc sulphate and copper sulphate. When dry these were built up in the appropriate way with a sheet of plain blotting paper between each pair of coatings, to represent the usual porous diaphragm, and the whole compressed in a screw press between rubber sheets as insulators. When built (Feb., 1903) the e. m. f. was one Daniell per cell or rather more. It then dropped to a steady, though lower, value for two and one-half years, registering 0.95 to 0.9 Daniell till July, 1905, when it was 0.9. Thereupon, dismounting the pile for examination it appeared to be unchanged, and on reforming it the same voltage was given, 0.9. After short-circuiting, the pile recovered its e. m. f. immediately. Of course, a very minute current only passed.

Tin Refining.—In the September issue of "Elektrochemische Zeitschrift," H. Mennicke begins to discuss the possibility of applying Betts' process of lead refining with modifications to the problem of tin refining. The present installment contains only some general introductory remarks.

Ozone.—In the July and August issues "Elektrochemische Zeitschrift," O. Kausch gives a summary of progress made in recent years in the production of ozone from silent discharges. Various new progresses are described from patent specifications.

Electrometallurgy of Iron and Steel.—A concise summary of the present situation with respect to the use of iron reduction and steel refining is given in a paper by R. S. Hutton in the "Jour. Soc'y Chem. Ind.," June 15; it contains no new details, but is an impartial, fair and conservative statement of the situation as it is at present. Mr. Engelhardt's elaborate paper on the Kjellin induction furnace, which was reviewed at great length in our August issue, is the subject of a long and well illustrated article in "Iron Age," Oct. 19.

Theoretical and Experimental.

Specific Heat of Iron at High Temperatures.—A careful determination of this quantity, which is of vital importance for metallurgical calculations, has been made in the (Brit.) National Physical Laboratory, the results being given in the October issue of the "Philosophical Magazine." The iron tested was very pure, the analysis being 0.01 C, 0.02 Si, 0.03 S, 0.04 P, trace Mn. The following table gives the results; total heat means total heat from 0° to T° C., and is given in calories; mean specific heat means the mean specific heat between 0° and T°:

T	200	300	400	500	600
Total heat	23.5	37.0	51.3	66.9	83.8
Mean specific heat..	.1175	.1233	.1282	.1338	.1396
T	700	800	900	1000	1100
Total heat	104.1	127.8	148.0	155.7	168.8
Mean specific heat..	.1487	.1597	.1644	.1557	.1534

The author states that the diminution at 900° and subsequent rise in the specific heat of iron require confirmation.

Specific Heat of Gases at High Temperatures.—The October issue of the "Phys. Rev." contains an account of an investigation carried out by L. Holborn and L. M. Austin in the German Reichsanstalt, on the specific heat of gases at temperatures between 20° and 800°. The gases were heated in an electrically-heated tube, and many precautions were taken which are described. The following table shows the mean of the observed values for the mean specific heat of the simple gases:

	Nitrogen.	Oxygen with 9.5 Per Cent. N.	Oxygen.	Air.	Air Circulated from N. and O.
Between 20° and 440°.	0.2419	0 2255	0.2240	0.2366	0.2377
" 20° " 630°.	0.2464	0.2314	0.2300	0.2429	0.2426
" 20° " 800°.	0 2497	.....	.....	0.2430	.....

The value for pure oxygen was calculated according to the known percentage of nitrogen mixed with it. In the same way a value was calculated for air, derived from the two values for nitrogen and oxygen. The following table gives the variation of the specific heat of carbon dioxide. In the column Cal the values given are derived from an empirical formula:

CO_2	Obs.	Cal.
Between 20° and 200°..........	0.2168	0.2173
" 20° " 440°..........	0.2306	0.2312
" 20° " 630°..........	0.2423	0.2410
" 20° " 800°..........	0.2486	0.2486

Titration Voltameter.—In the "Physik. Zeit." of Sept. 15, D. A. Kreider reports on a research made in Yale University on the construction of a titration voltameter for which a high accuracy is claimed. It is based on the liberation of iodine from an acidulated solution of potassium iodide and its estimation by means of sodium thiosulphate in a burette. The construction of the cell is shown in Fig. 6. The anode is placed at the bottom, and above the iodide solution, which forms the anolyte, a catholyte of lower specific gravity is used; it consists of a solution of hydrochloric acid. This prevents satisfactorily the iodine from diffusing towards the cathode and diminishing the current efficiency.

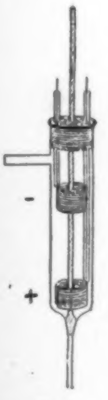


FIG. 6. TITRATION VOLTAMETER.

IRON AND STEEL.

Electric Properties of Steel.—At the first general Congress of Swedish Electrical Engineers, held in Stockholm, from Sept. 9 to 11, a paper on iron and steel for electrical purposes was presented by F. A. Enström, who, together with G. Dillner, had studied the influence of chemical composition and of manufacturing methods on the iron and steel used in electrical machines and transformers, at the testing laboratory of the Royal Technical University of Stockholm. The researches were made with sheet iron and with cast steel. The desired properties of the former are a low hysteresis loss and a high electric resistance, in order to keep down the eddy current losses. The main requirement in cast steel, which is used chiefly for pole pieces, is high permeability.

The instrument used for the researches was the Du Bois magnetic precision balance, which was accurate within some tenths of a per cent. With this instrument many different kinds of iron and steel, chiefly Swedish and German, were examined. At the first, samples were taken from the open market and later special samples, made expressly to contain different percentages of silicon and aluminium, were ordered. In casting the silicon steel it was observed that, with a percentage of this element above 1.5, the shrinkage of the steel is so great that cavities were difficult to avoid, while with about 1 per cent of aluminium there was no difficulty in casting the steel. With higher percentages of this element, however, the steel becomes rather thick, and from this cause many of the samples were unsound and unsuitable for testing. A chemical analysis of all the samples was made, the percentage of carbon, silicon, manganese, phosphorus, sulphur and aluminium being determined. The results obtained may be stated as follows:

For sheet iron it was found that the coercive force and the Steinmetz hysteresis coefficient is proportional to the carbon percentage within the range of 0.5 per cent. Thus it is obvious that a small amount of carbon is favorable in laminated iron for armature cores and transformers. In cast steel no determinal effect appears to be produced by increasing the carbon percentage. With the highest carbon percentage investigated, about 0.30 the values of the maximum induction and of the permeability at the usual induction in field poles are quite satisfactory. A high percentage of carbon produces an increase in the electrical resistance.

An increase of the silicon causes a quite noticeable increase of the coercive force and of the hysteresis loss and also of the electric resistance, while the properties of permeability, remanence and maximum induction hardly undergo any alteration. Therefore, for sheet material, silicon should be avoided, while in the case of cast steel some silicon in the material may be advantageous owing to its raising the electric resistance. More than 2 per cent, however, should be avoided, because otherwise there will be a tendency to form cavities.

It has been stated that an addition of aluminium quite noticeably reduces the hysteresis loss, whilst it increases the electric resistance, and thus reduces at the same time the eddy-current loss. It has been found, too, that an addition of aluminium will reduce the maximum induction and the permeability for ordinary saturation values. The general conclusion is, therefore, that an addition of aluminium improves sheet material for constructing dynamos. As regards cast steel, the matter is different. With such a high percentage of aluminium as is required in order to increase the electric resistance to an effective degree, the magnetic properties will be too much affected, and the usefulness of aluminium in cast steel is questionable, to say the least. It is of interest, however, to notice the results obtained from the researches on cast-steel rods containing both silicon and aluminium. In this case low hysteresis losses are found, to be ascribed, no doubt, to the influence of aluminium, while the influence of this element on the permeability and maximum induction seems to be neutralized by the addition of silicon. The addition of silicon and aluminium together seems thus to tend towards a general improvement of the magnetic properties.

C. Benedicks has given a formula for calculating the electric resistance of iron from the number of atoms present of any element, which is contained in the iron in solid solution. This formula has been tested, and the agreement considered very close. (A summary of Benedicks' researches will be given in a future issue.)

It has been found that, as a rule, annealing improves the magnetic properties in general, and especially decreases the hysteresis loss. As to sheet material that had been annealed in packs, a decided difference amounting to about 10 per cent in favor of the edges was found between the edges and the center, regarding coercive force and hystere-

sis loss. These researches prove, therefore, that the general assumption that the edges contain a lower grade of material than the center, is false. The time and temperature of the annealing is very important, 147° F. seems to be the best temperature.

The researches have shown that the Swedish-Lancashire forge process and the basic open-hearth process gives the best steel, next comes the acid open-hearth process, while the Bessemer process gives a much lower grade of material, possibly because the Bessemer steel has a greater opportunity of dissolving gases when the air is passed through the bath of molten metal.

During the discussion following the reading of the paper, the question of the ageing of the material was brought up, and it was pointed out that the ageing depends largely on the annealing. If the annealing is carried out at the proper temperature the danger of ageing is very small. Regarding the advisability of annealing the laminated packs after punching, it was stated that Swedish and German manufacturers have abandoned this method which, however, is still in use in America and England.

Cleaning Blast Furnace Gas.—In the October issue of "Cassier's Magazine," A. Sahlin discusses the economies which may be attained by cleaning the blast furnace gas before further use. According to the different uses to which the gas is later to be put, different methods of cleaning with corresponding results, should be adopted. The gas engine would do its best work with absolutely pure gas; it does not work well with gas containing above about 0.044 grain per cubic foot. Stoves and boilers on the other hand do not require the cleaning to be carried beyond 0.130 grain per cubic foot. When the gas is to be used in engines, the cleaning cannot be carried too far, while for use in stoves, furnaces, kilns or under boilers it would be an extravagance to seek to remove the very last fraction of a grain. The author recommends the adoption of a three-stage process. The first stage should consist of the employment of gravity and centrifugal force to deposit such heavy particles as can be separated by these forces. The proper instrument for doing this is a circular dust-catcher, into which the gas is introduced near the bottom in a tangential direction, and whence it is removed through a central pipe connecting with the top of the dust-catcher. The larger such a dust-catcher is the better. At a modern plant in the north of England, a dust-catcher having a diameter of 21 feet, and a height of 80 feet, is employed with good results. This first stage of the cleaning is performed without any tangible cost or expenditure of power. When issuing from the dust-catcher the gas may contain from 0.66 to 2.84 grains per cubic foot. This dust is so fine that it will float in the gas for an indefinite period. It must be removed by cooling the gas by contact with water and with surfaces sprayed with water. For this purpose different machines have been invented, all of which may be divided into the following classes: Stationary cleaners, slowly-revolving fresh-contact cleaners, rapidly-revolving or atomizing cleaners. Several kinds of apparatus of these types are described and illustrated. Rapidly-revolving or atomizing cleaners or fans are effective cleaners, but require considerable power in proportion to the volume of gas cleaned. At the de Wendel Works, at Hayange, the entire quantity of gas from seven blast furnaces is cleaned by fans only, and with gratifying results. The cleaning is carried on in three stages, namely, by means of large fans, which leave about 0.2 gram of dust per cubic meter of gas, which is then sent to the stoves and boilers. The second cleaning is carried on in smaller and more rapidly-revolving ventilators, and leaves less than 0.1 gram of dust per cubic meter of gas. This small quantity is still further reduced by passing the gas through a scrubber before it is carried to the large central electric power plant, which has a capacity of 7,000 hp. In 1900, Thiessen designed a modification of the ventilator. The Thiessen apparatus consists of a conical shell revolving on a central shaft placed inside of a conical containing shell. To the outer surface of the inner cone, fan blades are riveted at different angles. Gas enters the apparatus at the small end of the containing cone, and is drawn off at the large end. Numerous pipes, arranged along the sides of the outer shell, admit water. The gas is thoroughly cooled, that is, dried, and is freed from dust.

RECENT METALLURGICAL PATENTS.

Tin.

In the smelting of tin ores, slags are obtained which, even after repeated smelting in reverberatory or blast furnaces, still contain a certain percentage of tin in the form of ferrous stannate or silicate of tin. C. A. L. W. Witter (801,290 and 801,820, Oct. 10) patents a process by which, he claims, the tin contents of the slags can, with profit, be extracted even down to 0.5 per cent or less, the slags being smelted and reduced in a blast furnace adapted as a hearth-furnace together with lead, lead ores or other plumbiferous materials. In this way an alloy of lead and tin is obtained, the lead serving as a solvent for the tin reduced from the slags. In order to remove the iron, there is added to the slags on smelting, together with the lead, a quantity of sulphur, or material yielding sulphur, corresponding to the iron to be separated, so that the iron as it separates is instantly bound with the sulphur, and on drawing off, the alloy can be removed as a matte from the furnace.

The alloy of tin and lead thus obtained contains a very large proportion of lead. The alloy is melted in a reverberatory furnace, and when the temperature is such that the molten mass shows a red glow, an air-blast is blown on the molten mass. The tin in the alloy is oxidized, but at the same time a certain portion of the lead is oxidized as well. An oxide mixture containing a high percentage of tin is thus obtained, which can be drawn off the surface of the metal bath and then again reduced in a reverbatory or blast furnace to form an alloy containing a large proportion of tin.

Preventing Corrosion of Metallic Screens in Ore Dressing.

Two patents of H. S. Anderson and J. W. Bennie (796,172 and 796,390, Aug. 1) are interesting, since an undoubtedly sound principle of electrochemistry is applied in the same to a new purpose. The metallic screens used in concentrating jigs and similar apparatus are subject to great wear, due to the corrossive action of acids, alkalies or salts in the water used for concentration. To prevent this corrosion, the inventors make the screen the cathode or electronegative element of an electrolytic cell. This may be done in two ways. A second electrode (acting as anode) is required in either case; it is placed on the slanting bottom in the tank below the screen. This second electrode may be made of graphite (not attacked by the solution), and the screen and this graphite plate connected to a dynamo outside of the cell; or the second electrode may be made of zinc and electrically connected with the screen. In the latter case we have a short-circuited cell. If the screen is made of copper and the concentrating liquid contains sulphuric acid or copper sulphate, as is usual in the treatment of ores containing copper sulphide, the electrochemical action will prevent any oxidation or corrosion of the screen; on the contrary, either hydrogen will be set free on the screen or copper deposited on it, thus building up the screen in opposition to the abrasive action of the ore. By thus sacrificing "an inexpensive material in an inexpensive form" (electrical energy in the first case and zinc in the second case) the inventors protect the more expensive screens against corrosion and abrasion. They state to be able to use steel wire or punched steel screens, many times less expensive than brass or copper. It would be very in-

teresting to get exact data as to the cost of the method, compared with the saving. Such data can be obtained only by practical operation on a large scale and extending over a sufficiently long period. The principle is, of course, the same as the use of zinc for the protection of boilers and condenser tubes on vessels, which application has proven commercially successful.

MAGNETIC CONCENTRATION.

The commercial importance of magnetic concentration is indicated by the number of inventors working in this field. J. P. Wetherill (801,947, Oct. 17) patents details of a system in which several magnetic concentrators are used in series, the material not attracted by the first magnet being subjected to a second magnetic concentration and so on.

H. H. Campbell (790,342, May 23) provides a system of magnetic concentration similar to water concentration. There is an inclined table with a diagonal row of electromagnets. These magnets are reciprocated in a direction lengthwise of the table. At the end of their forward stroke the magnets are demagnetized, and immediately before they reach the limit of their return stroke they are remagnetized. The magnetic particles are thus forced to travel in a diagonal direction, being subjected both to magnetic attraction and gravity, while the non-magnetic particles descend simply under the action of gravity.

E. Langguth (793,137, June 27) patents details of construction of separators in which a non-magnetic screen is interposed between the active surfaces of the magnets and the material, and the latter is conveyed along the screen, and thereby distributed according to the magnetic properties of its constituents. The invention consists in a specific disposition of the rotating parts of the active electromagnet by which the field is divided into a number of radially-disposed stripes, which retain and convey the magnetic particles of the ore and permit the non-magnetic material to drop out between the radii as the latter in rotating approach a vertical position.

L. T. Weiss (791,305, May 30) endeavors to extend the application of magnetic concentration to the separation of gold particles from sand and quartz with which it is mixed. For this purpose the mixture is passed through an electroplating tank in which the gold particles are coated with a film of iron. This is then followed by magnetic concentration.

BOOK REVIEWS.

ENGINEERING CHEMISTRY. By Prof. Thomas B. Stillman. Third edition. Easton, Pa.: The Chemical Publishing Co. Price, $4.50.

Prof. T. B. Stillman, of the Stevens Institute, has revised his "Engineering Chemistry" to July, 1905. This excellent book is founded on the series of lectures he gives to the students of Stevens, and covers the ground of analysis, chemical engineering and metallurgy needed by an engineer. Although some important subjects are omitted, due, we suppose, to the fact that others are taken up in detail, nevertheless, the practical nature of the chapters are enough to make the volume a valuable one to the chemist and metallurgist as well as to the mechanical engineer.

Among the prominent features are up-to-date analytical methods; water for sanitary or boiler purposes; practical calorimetry; producer gas; coal and coke, Portland cement, building stone and brick, etc., etc. In fact, we can but recommend this book most heartily, for it is written for the needs of the practical man and fulfills the purpose for which it was designed.

Highly Sensitive d'Arsonval Galvanometer.

To the numerous types of d'Arsonval galvanometer, made by the Leeds & Northrup Co., Philadelphia, recently a new one has been added which is considered to be the most refined instrument of the series. It is particularly intended for those who make considerable use of a very sensitive galvanometer for technical measurements or for purposes of research.

In design it is a radical departure from the old style laminated magnet with suspension tube, which permitted but small clearance for the coil and in which the suspended system was not visible.

The following features of the improved design render this highly sensitive instrument very convenient for practical use.

Through the large open-glass front the entire system is always exposed to view, and when anything is wrong with it the trouble can be readily detected.

In such cases the removal of the tube containing the moving system is readily effected by the loosening of two thumb screws. The tube may then be removed from the magnet and laid horizontally on a table, which is often of great convenience, if any adjustments are to be made, such as the insertion of a new suspension.

The upper suspension is protected against breakage by being attached to a small spiral spring just strong enough to sup-

GALVANOMETER.

port the coil. When the instrument is jarred, or the coil is knocked, the spring yields and protects the suspension. This arrangement does not change the manner of adjusting the zero or the length of suspension required, nor makes it more difficult to put in a new one.

The tube has at its back a simple device for clamping the coil, so that the galvanometer and tube may be moved about.

The coil is of the rectangular type, similar to the Leeds & Northrup type H coil, but is made smaller, so that the system will be lighter, and give a greater sensibility with a given period of swing.

A small index point on the coil shows when the galvanometer is exactly level and the coil is swinging centrally in the field.

To provide the highest possible insulation, the entire galvanometer is insulated from earth by means of three hard rubber leveling screws, terminating in steel points. The bottoms of the leveling screws have deep grooves turned in them, thus making a "petticoat" insulation.

Stoneware Apparatus for Chemical Purposes.

In a very interesting paper presented a few years ago before the American Electrochemical Society (our Vol. I., p. 62, "Transactions"; Vol. II., p. 290), Mr. David H. Browne pointed out that the successful conduct of any electrochemical process depends not only upon the care with which the electrical and the chemical parts of the subject are worked out, but to a great extent upon the mechanical questions involved and the means provided for conveying the solutions to the baths and disposing of the products of the same. The same is really true of every chemical process. In the paper mentioned, Mr. Browne recorded in a most interesting and humorous way the troubles which he has had in many years' work with pumps and other accessories in chemical operations. A considerable part of his paper dealt with stoneware apparatus, which have proven extremely suitable for many chemical purposes.

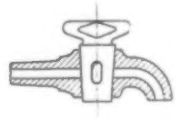


FIG. 1.—STONEWARE COCK.

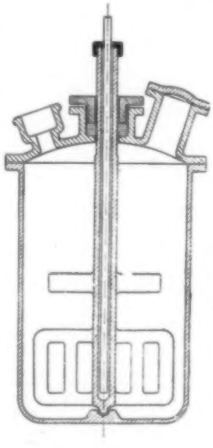


FIG. 2.—STONEWARE STIRRER.

In connection with this subject, a paper presented by Prof. Georg Lindner, in Karlsruhe, before the Association of German Engineers, and published in this year's volume of the *Zeitschrift des Vereins Deutscher Ingenieure*, contains much of interest, giving a review of the various stoneware apparatus which are now being built in Germany for chemical purposes.

The author also gives mathematical formulas for the calculation of centrifugal pumps and exhausters, for which the readers may be referred to the original German paper. In the following we will mainly reproduce drawings of the stoneware apparatus described by Prof. Lindner. These drawings are quite interesting, since they clearly indicate the details in design in which they differ from patterns made of iron. In order to get the necessary mechanical strength the designs had, of course, to be changed in many details.

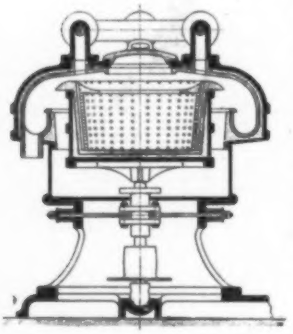


FIG. 3.—CENTRIFUGAL MACHINE.

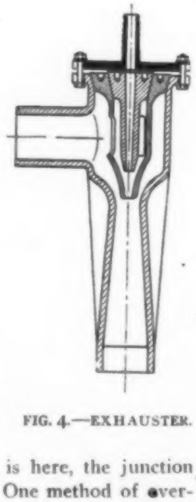


FIG. 4.—EXHAUSTER.

Fig. 1 shows a stoneware cock. Its design presented originally difficulties with respect to tight fitting, but these difficulties are considered to have been completely overcome long ago.

Fig. 2 is a sectional diagram of a stirring apparatus; the vertical axle of the stirring mechanism is continued outside of the apparatus in form of a wrought iron shaft coupled to the driving motor. The main difficulty is here, the junction between the axle and the driving shaft. One method of overcoming this difficulty is to make the axle of the stirring mechanism hollow, and insert in its interior the driving shaft, the space between the driving axle and the interior surface of the hollow shaft being filled with sulphur or concrete.

Fig. 3 shows a centrifugal machine in which the number of revolutions of the drum is 800 per minute, the internal diameter of the stoneware drum being 850 mm. In order to protect the drum against cracking, it is covered with a mantle of sheet steel. An interesting conclusion from exact calculation is that a mantle of cast iron would not do, because when revolving with the same speed the cast-iron mantle would expand more than the stoneware drum, so that the latter would not be protected. The liquid rises along the walls of the drum and is thrown over the rim into the outer casing, the internal surface of which is also made of stoneware. The top of this casing contains an opening for filling and lateral pipes for sucking off acid vapors. The many small holes in the walls of the drum do not pass through to the outside, but each vertical row of these perforations connects with a canal inside of the stoneware wall and reaching up to the rim. The canals, like the walls, are nearly vertical, the slope being 10 to 1 or 12 to 1, so that at speeds above 150 r. p. m. of liquid is thrown out of the canals at their upper end.

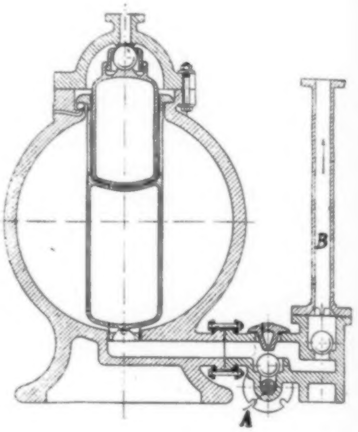


FIG. 5.—MONTEJUS APPARATUS.

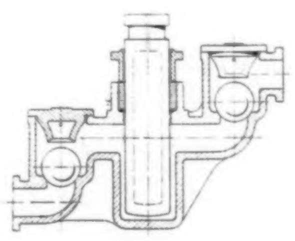


FIG. 6.—PISTON AND PLUNGER PUMP.

Fig. 4 shows the Guttman exhauster, which is specially adapted for sucking off gases with steam or compressed air. These exhausters are made for a tube width of 50 to 450 mm.

Fig. 5 shows the "Montejus" apparatus in which the liquid is driven out of a closed vessel by means of compressed air into the tube B and thus raised. After the closed vessel has been emptied the air valve is turned off and the enclosed air escapes, whereby the vessel is filled again with a liquid from a higher reservoir through a tube with a suitable valve. The liquid enters through A. Fig. 5 shows an improved construc-

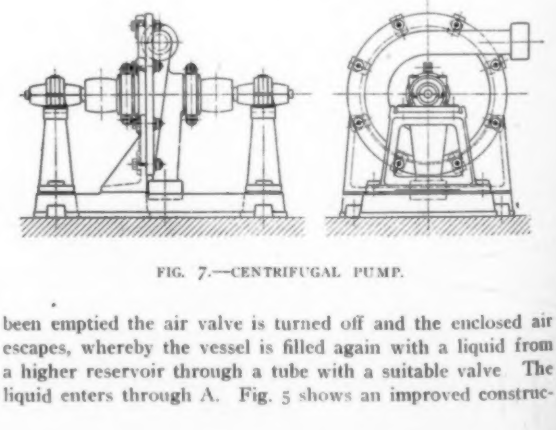


FIG. 7.—CENTRIFUGAL PUMP.

tion operating with the expansion of the compressed air in order to utilize perfectly its capacity of work. The opening and closing of valves is, of course, performed automatically.

Fig. 6 shows a piston and plunger pump with iron frame and gearing. The valves are polished stoneware balls, which are

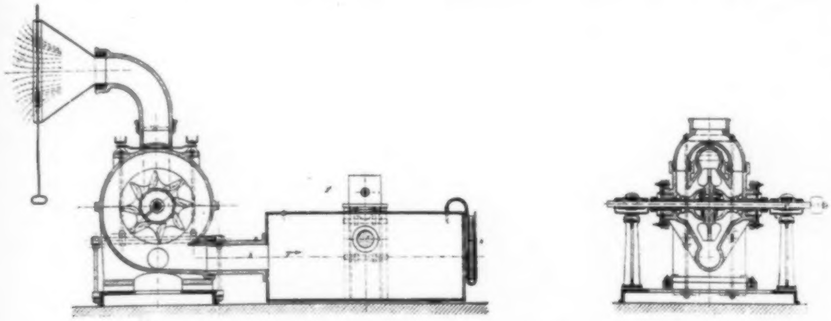


FIG. 8.—STONEWARE EXHAUSTER.

covered in some cases with rubber. Rubber rings, cotton impregnated with paraffin or asbestos are used for packing.

Fig. 7 shows a centrifugal pump; the width of the pipe is 50 mm., the diameter of the fan 300 mm. At 1000 r. p. m. it raises per hour 12 cubic meters to a height of 10 meters. Some tests made with this pump are discussed by Prof. Lindner at some length on the basis of mathematical analysis.

Fig. 8 shows a stoneware exhauster running at a circumferential speed as high as 35 to 45 meters per second. The capacity of these stoneware exhausters are very satisfactory. They are built in sizes of 300, 200 and 150-mm. width of tube. The gases have a normal speed of 10 to 20 meters per second. The maximum effect is therefore for the three sizes 80, 40 and 20 cubic meters per minute, respectively. For more special details reference may be made to *Zeit. f. Angewandte Chemie*, 1903, No. 49, and 1905, No. 6. The box II. at the right-hand of the left-hand diagram of Fig 8 was used in the tests of the author.

The Deutsche Steinzeugwarenfabrik für Kanalisation und Chemische Industrie, in Friedrichsfeld i/B., which make these stoneware apparatus, is represented in this country by Mr. Frederick Bertuch & Co., of New York City.

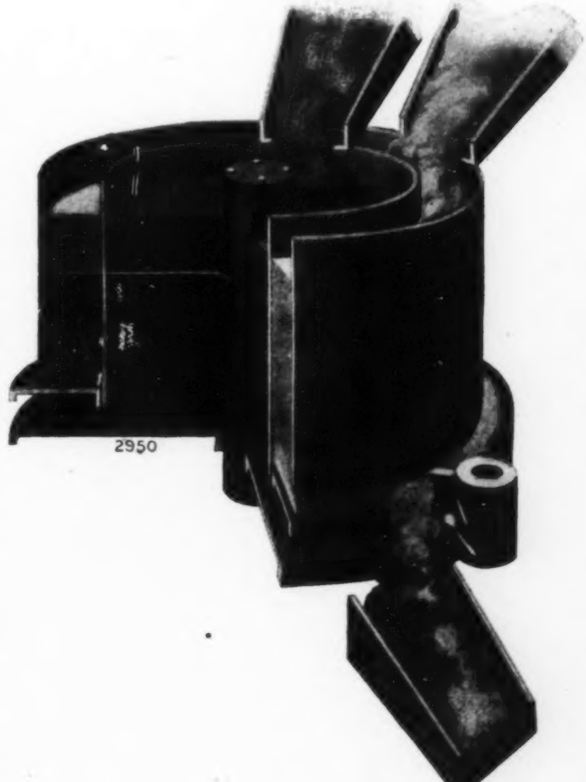
A New Machine for Measuring Materials.

We have repeatedly referred in our columns to the problem of continuous versus intermittent operation in metallurgical and chemical practice, and have pointed out the natural tendency of using continuous processes wherever the object is to push the production to a maximum.

Where materials are to be fed to metallurgical apparatus, to kilns or furnaces, the intermittent introduction from weighing machines, cuts down the capacity of the apparatus to considerable extent. However, weighing can only be done intermittently, so that if the materials fed into the apparatus are measured by weighing them, the feed is necessarily intermittent. Moreover, while scales accurate in themselves can readily be obtained, yet where the scale hoppers are fed from overhead hoppers, the cut-off gates often introduce error through failures to stop the flow in time, particularly with fine materials. If men close the gates by hand they sometimes get careless and inattentive. If the scales operate the gates automatically, they do not begin to operate until the scale beam tips, and all material entering between that time and the complete closing of the gates is in excess of that actually weighed.

The Trump measuring machine, which will be described in this note, is an accurate means of determining the mass of the material by volume rather than by weight.

In measuring granular materials or powders allowances must, of course, be made for the proportion of voids, and it would seem at first sight that this might be a considerable source of error. Materials produced by different companies may vary in the proportion of voids, as they are prepared by different methods and different machinery, so that a cubic foot of clay, for example, may mean anywhere from 80 to 100 pounds, depending on what preparation it has received. Clay dug from the same bank and crushed in the same crushers will weigh the same now, 5 minutes, an hour, day or month hence, the only variation being that due to the slow wear of the machinery which prepares the substance. This is the condition obtained in most factories, so that the proportion of voids can be easily ascertained and allowed for. The variation due to wear is slow and slight, and is corrected by tests at infrequent intervals. Measuring, therefore, is more accurate than weighing



MEASURING AND MIXING MACHINE.

where each batch weighed may be different, provided that the measuring apparatus does its work accurately.

Before the invention of the Trump measuring machine, measurement was not considered sufficiently accurate, principally because of inaccuracies introduced by the measuring device itself.

Rolls with pockets often did not clear themselves perfectly,

and in many cases were affected by the depth of material in the overhead hoppers, which caused a variable density.

Screw feeds wore to smaller diameters very quickly with gritty substances, and so decreased the amounts fed out. With fine, powdery materials they would sometimes flush through, regardless of the screw, and sometimes hang back. Even at its best the screw delivered pulsating feed.

Years ago a device was invented consisting of a circular revolving table, on which was a conical pile of material to be measured, this pile being constantly replenished from a stationary spout some distance above. The measuring part was a stationary blade extending diagonally into the pile near the table.

It was only partially successful for two reasons:

First, the spout and the material in it being stationary, and the table with the material on it revolving, there was a zone where it was neither quite stationary nor yet moving quite at the speed of the table. The zone was not fixed in its position, but raised and lowered according to the varying consistency of the materials, dampness, etc. Consequently, the spout had to be some distance above the table to insure that the zone never was as low as the cutting blade.

Secondly, the spout being such a distance above, left a long slope of the material unsupported. Accidental jar, dampness, etc., would cause some little variation in the slope. Very slight changes would cause considerable variation in the diameter at the bottom of the pile, because of the length of the slope. This meant a corresponding variation of the distance which the knife extended into the pile, and consequently serious inaccuracies in the result.

The device, however, was automatic, continuous, cheap to operate, and satisfactory when great accuracy was not desired, or where the materials were not too fine.

The Trump measuring machine operates on the same principle of the revolving table and stationary knife, but the cylindrical supply spout is made to revolve with the table. There is, consequently, no zone of irregular motion, and the cylinder can therefore be brought down close to the upper edge of the knife, reducing the unsupported conical slope to a minimum, so that changes in the angle have little effect on the total diameter of the pile. The material being at rest at all times also reduces the liability of the slope to change.

The cylinder is also made larger, nearly the diameter of the table, so that the knife can cut deeper; and of the amount cut off, the slope is a very small part. Repeated tests show that the Trump machine has worked well within a ½ per cent variation—more accurate than scales in the same situation, and cheaper to operate.

The cutting blades, or "knives," are cast with a bell crank lever, which connects with a micrometer screw adjustment, so that the amount pared off per revolution can be varied at will. A dust-proof casing surrounds the measuring cylinders, to prevent loss of the finer materials or pollution of the air.

When more than one material is to be measured, a table and cylinder are provided for each material—the tables are superposed and the cylinders placed one within the other, as shown in the adjoining diagram.

These machines were designed for use at the works of the Solvay Process Co., by Mr. E. N. Trump, chief engineer of that company. They were so successful that Mr. Trump protected his rights by patent, and arranged with the Link-Belt Engineering Co., of Philadelphia, for the manufacture of them.

The machines have been with perfect success, for such varying purposes as the feeding of kilns, the mixture of chemicals, manufacture of coke briquettes, feeding of rocks, making of concrete, etc., and materials have been handled with it of 6-inch cube dimensions to the finest of powders, both wet and dry.

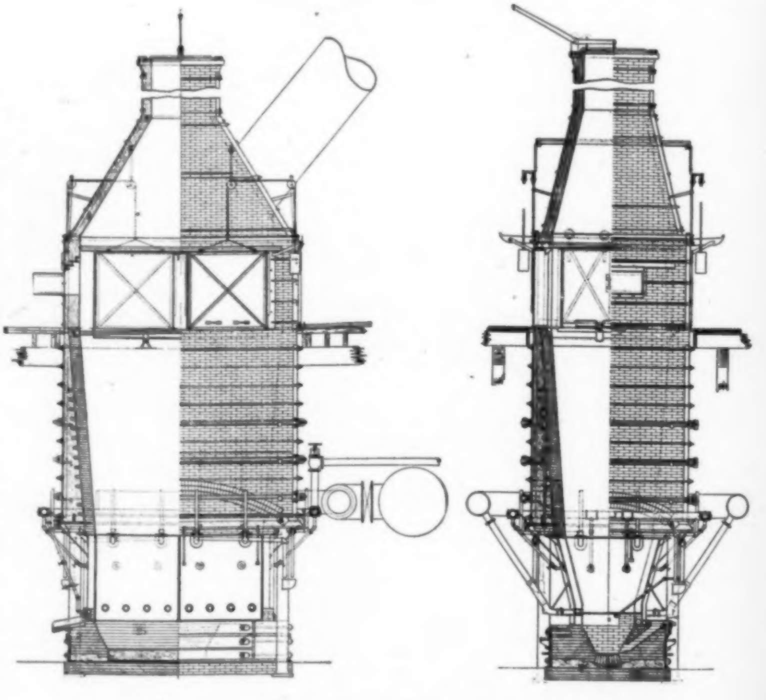
Blast Furnaces for Lead and Copper Smelting.

Smelting is an exact science. Given a certain ore with proper fluxes and proper attendance, it is possible to predict almost exactly the result that will be obtained in a smelting furnace of modern construction. The modern smelting furnace is the result of a process of evolution. It has been developed by the coöperation of the metallurgists at the smelting plant with the manufacturers of smelting furnaces.

The following notes describe the latest types of blast furnaces, both for lead and for copper smelting, made by the Allis-Chalmers Co., as the result of some forty years experience as manufacturers of machinery for the mining and reduction of ores. Small furnaces are made round and will not be considered in the following. Large furnaces are built rectangular in shape. All the dimensions given in the following are measurements made inside the jackets of the tuyere line.

Blast Furnace for Lead Smelting.

The general design of the modern 44-inch x 144-inch steel water-jacketed lead furnace, made by the Allis-Chalmers Co.,



FIGS. 1 AND 2.—RECTANGULAR STEEL WATER-JACKETED LEAD FURNACE, 44" x 144".

is shown in Figs. 1 and 2, which give a half section and end elevation. The curbs of these furnaces are of steel or cast-iron plates, resting upon a steel-bottom plate, and very strongly bound on the outside. The jackets are made of the best flange steel, having either welded or riveted joints, and are braced between the front and back sheets by our special steel stays.

No rivet heads appear anywhere on the front sheets. All jackets are provided at their sides with heavy steel lugs and bolts for binding them to the adjoining jackets, and the entire set of jackets is bound together by strong steel binders encircling the jackets, or by jackscrews, resting against the mantle frames or a binding frame provided for that purpose, encircling the furnace outside of the main columns.

Suitable tuyere openings are provided in the side jackets near the bottom of the jacket. Tuyeres are seldom placed in the end jackets of modern lead furnaces. Tuyeres of the usual lead furnace type, such as those shown in Figs. 1 and 2, are connected with the bustle pipe by flexible canvas tubing or, if desired, rigid tuyere boxes connected to the bustle pipe by light steel tubing are provided. The bustle pipe is built of heavy galvanized steel. It is provided with a main flanged nozzle for connecting it to the main blast pipe, and with connections for the tuyere pipes, and is supported from the mantle frame or furnace shaft.

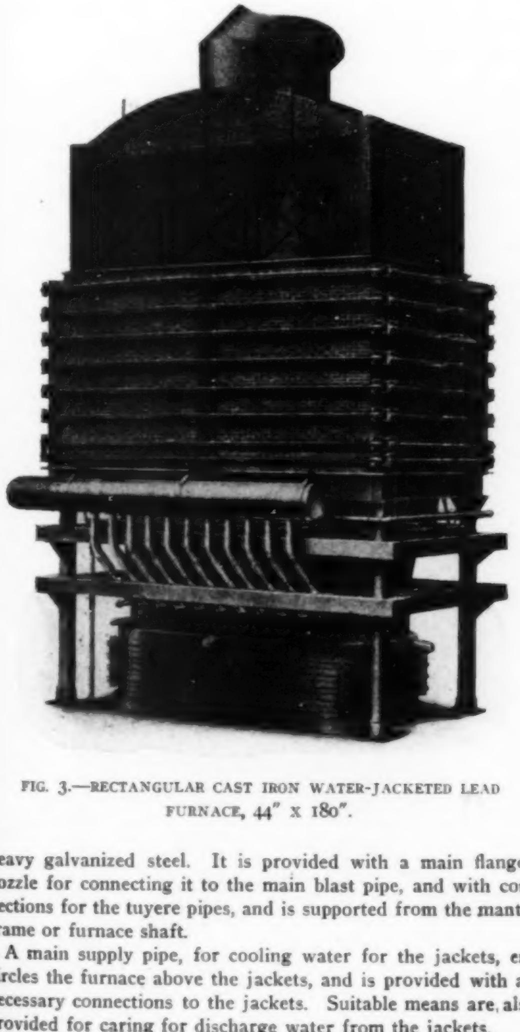


FIG. 3.—RECTANGULAR CAST IRON WATER-JACKETED LEAD FURNACE, 44" x 180".

A main supply pipe, for cooling water for the jackets, encircles the furnace above the jackets, and is provided with all necessary connections to the jackets. Suitable means are also provided for caring for discharge water from the jackets.

The brick shaft above the jackets rests upon a mantle frame built up either of heavy cast-iron sections or of "I" beams, as desired. This is carried by columns at the corners of the furnace. The shaft is bound on outside by heavy corner binders, tied to the opposite corner binders by heavy steel rods. When the furnace is of the "flush-top type" the shaft terminates at the charging floor, the top being covered by cast-iron or steel plates with suitable openings provided in it for charging the furnace, and a connection for the downtake just below the charging floor. When the furnace is of the hood type, as shown in Figs. 1 and 2, the shaft extends 6 to 10 feet above the charging floor level, and is covered by a brick or sheet steel hood, terminating in a brick or sheet steel stack extending up through the roof of the building, with the downtake connecting at a suitable place in the hood or stack. In this style of furnace, charging openings are provided at the sides of the shaft at the feed floor level. These openings are provided with counterweighted steel doors. The stacks of these furnaces are provided with dampers, which are kept closed, except when the furnaces are being blown in, or out, of service.

Cast-iron jackets are preferred by many metallurgists for lead furnaces. Fig. 3 shows a 44-inch x 180-inch modern lead furnace, having cast-iron jackets.

Steel-plate jackets are used on account of their great durability, and the relief they afford from the cracks, blow-holes, shut-downs and complicated construction common to cast-iron jackets. The life of a steel-plate jacket is almost entirely dependent upon the care it receives. Given sufficient cooling water and cleaning from scale, and it will last for years. On the other hand, a cast-iron jacket is liable to crack the first hour it is in service, no matter how well it may be made or cared for, and, at best, its life is very short compared to that of a steel-plate jacket. In addition, as cast-iron jackets are necessarily made in small sections many more of them are required for a furnace of a given size than of steel-plate jackets, hence a more complicated construction and more attenion required in their erection and operation.

The capacity of a lead furnace depends chiefly upon the character of the ores treated, although much also depends upon the man in charge and upon the design of the furnace itself. The furnaces of the Allis-Chalmers Co. are rated ordinarily at a capacity of about 3 1-3 tons of charge per 24 hours per square foot of area at tuyere level; that is, a 36-inch x 120-inch furnace is rated at 100 tons capacity per 24 hours. This capacity is generally exceeded, especially by large furnaces.

The amount of fuel required also depends upon the above-mentioned conditions, and also varies materially with the character of the fuel itself. In small lead furnaces using coke as much as 20 per cent of the weight of the charge may be necessary, while with large furnaces as little as 10 per cent is sufficient. A general average may be assumed, however, at from 12 per cent to 14 per cent of the charge. When charcoal is used, a somewhat larger quantity will be required.

Coke is the most satisfactory fuel for blast furnaces ,as owing to the strength of its structure, it does not readily crush under the weight of the charge in furnace. Charcoal, however, is very satisfactory for small furnaces.

BLAST FURNACE FOR COPPER SMELTING.

Blast furnaces for smelting copper ores are similar in general form to those used for lead smelting, but in detail they differ from them materially. The internal crucible is either shallow or is dispensed with entirely, as in the case of matting furnaces, where the molten materials pass at once from the furnace into an external crucible known as the "settler," where the separation of the matte and slag takes place. The jackets are much higher than in lead furnaces, extending in many furnaces up to the charging floor. In this case they are made in two tiers or sections. Invariably the water-jackets are made of steel plates. The tuyere boxes are of the rigid type and connected with the bustle pipe by light steel tubing. The mantle frame and supporting columns and the structure above the mantle frame are much the same as for lead furnaces. Large copper furnaces are built rectangular in shape; small furnaces round.

Fig. 4 illustrates the standard design of the Allis-Chalmers Co. for rectangular matting furnaces up to 42 inches x 120 inches in size. The bottom of this furnace is formed by a heavy cast-iron plate resting upon jackscrews, which are carried upon a steel truck mounted upon flanged wheels. In many furnaces the truck is omitted, the jackscrew bases resting upon the furnace foundation. The jackets rest directly

upon the bottom plate, but are hung from the mantle frame by suitable hangers, so that when the bottom plate is lowered the jackets remain in position suspended from the mantle frame. The jackets are made in sections, of steel plate with riveted joints, and are stayed between the front and back sheets by improved steel stays. No rivet heads appear anywhere on the front sheets of the jacket. One side of the jacket is provided with a recess at the base for a rectangular tapping jacket, used for draining the furnace when blowing

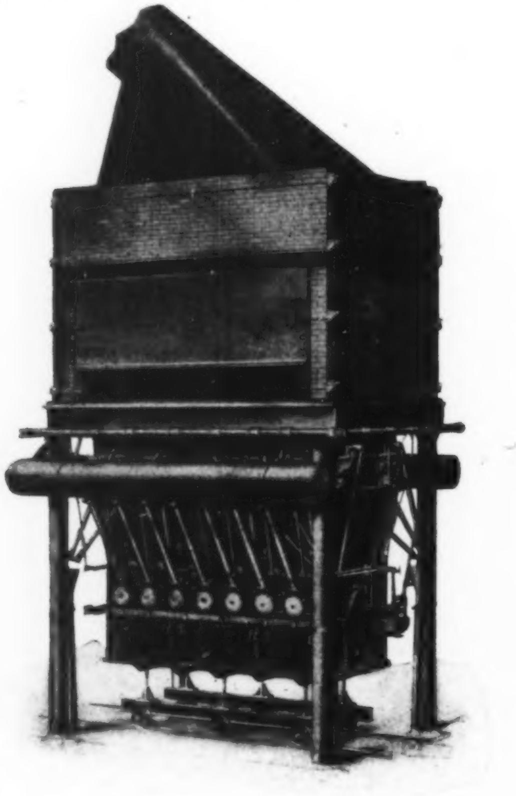


FIG. 4.—COPPER BLAST FURNACE, 42" X 120".

out of service. One end jacket is provided at its base with a recess for inserting a rectangular breast jacket, in front of which sets the trap-spout and through which the molten materials flow to the settler. The Allis-Chalmers Co. usually makes the side tapping jacket of cast iron. As this is not used often it does not require a more durable or more expensive material. The breast jacket and trap spout are made of either a special bronze mixture or of steel plate, as they are constantly in use and require very durable materials to give satisfactory service. All jackets are provided at their edges with strong lugs and bolts for securing them to adjoining jackets, and the entire set are bound by steel "I"-beam binders on each side and end of the furnace, held together at the corners by strong "U" bolts. All jackets are provided with inlet and outlet connections for cooling water, hand-holes at the base for cleaning and all other fixtures and fittings complete.

The tuyere boxes are bolted rigidly to the back of the jackets and connected to the bustle pipe by light steel tubing. The bustle pipe is of steel plate, provided with a main flanged nozzle for connecting it with the main blast pipe, and suitable nozzles on each leg for connecting the tuyere pipes.

The mantle frame is of very heavy steel "I" beams, and rests upon four cast-iron or steel columns at the corners of the furnace. A cast-iron plate rests upon the middle frame, forming a base for the brick work of the shaft. The furnace shaft is made of good common brick and lined on the inside with 9 inches or more of firebrick. At the charging floor level openings are provided in each side of the shaft, the full length of the shaft, for charging the furnace. The bottom and sides of these openings are protected by heavy cast-iron plates and the top of the opening is formed by a steel "I"-beam lintel frame, which carries the brick work of the shaft above the charging openings. Stationary light steel curtains from the lintel frame are provided to cover the charging opening to within 12 to 18 inches of the floor level, leaving just opening enough below the curtain to shovel the charge into the furnace. These curtains can be easily removed for barring down, furnace inspection or other purposes. The top of the furnace shaft is covered by a pyramidal shaped steel hood terminating in a connection for a round steel downtake or stack.

Fig. 5 shows the standard design of the Allis-Chalmers Co. rectangular copper furnaces of the larger sizes. These furnaces are much the same as those shown in Fig. 4, excepting that they have a second tier of jackets, directly above the lower jackets, which extend almost up to the feed floor.

Modern copper blast furnaces attain, on an average, a capacity of from 5 to 6 tons of charge per 24 hours per square foot of area at the tuyere level. Many furnaces greatly exceed

FIG. 5.—WATER-JACKETED COPPER FURNACE, 44" X 160".

this capacity, and this rating is only given for approximate calculations.

Coke is, of course, the most desirable fuel for copper furnaces, although charcoal is frequently used for small furnaces. The quantity of fuel required varies, according to conditions, from 7 per cent to 8 per cent of the weight of the charge in large furnaces handling heavy sulphides up to 16 per cent to 18 per cent in small furnaces treating oxide and carbonate ores. This is, of course, using a cold blast. When smelting sulphide ores with a host blast, as low as 2 per cent of coke has been used with satisfactory results.

News and Notes.

American Electrochemical Society.—The next meeting of the Society will be held in Ithaca, N. Y., on May 1, 2, 3, 1906. At the meeting of the Board of Directors, held in Philadelphia in Oct. 7, the following gentlemen were elected members of the Society: Frank T. Colcord, Maurer, N. J.; William F. Oesterle, Waukegan, Ill.; Coloman E. Nutter, Topeka, Kan.; John Meyer, Philadelphia, Pa: Frank K. Cameron, Washington, D. C.. At the next meeting of the Board of Directors, to be held on Nov. 4, the names of the following gentlemen will come up for election to membership: Leonard Waldo, Plainfield, N. J.; W. B. Jadden, Marion, Ind.; William Smith, Philadelphia, Pa.; Carl P. Goepel, New York City.

New York Section Society of Chemical Industry.—The first meeting of the season was held at the Chemists' Club on Oct. 20, the topics of the evening being an account of the annual meeting in London, and of the visits to the English sections of the Society, which have already been reported in this journal. Dr. Parker was presented with a gold watch and fob in recognition of his active work in connection with this trip.

New York Electrical Society.—On the evening of Oct. 23, Mr. Peter Cooper Hewitt lectured before the New York Electrical Society on electrical reactions of gases, with particular reference to the phenomena found in the Cooper Hewitt mercury vapor lamp and rectifier.

Sixth International Congress of Applied Chemistry.—The sixth International Congress of Applied Chemistry will be held in Rome in the spring of 1906. The president of the committee of organization is Prof. Emanuele Paterno, Via Panisperna, Rome, and the secretary, Prof. Vittorio Villavecchia, Central Customs Laboratory, Rome. The subscription fee for active membership is 20 francs, and is to be remitted to the secretary before the opening of the Congress or during its session. The Congress is divided into the following eleven sections: 1. analytical chemistry, apparatus and instruments; 2. inorganic chemistry and industries relating thereto; 3. metallury and mining and explosives; 4. organic chemistry and industries of organic compounds and coloring matters; 5. technology and chemistry of sugar; 6 fermentation and starch; 7. agricultural chemistry; 8. hygiene and medical chemistry, pharmaceutical chemistry, bromatology; 9. photochemistry; 10. electrochemistry, physical chemistry; 11. laws, political economy and legislation in relation to industrial chemistry. Dr. H. W. Wiley, chief of Bureau of Chemistry, Department of Agriculture, Washington, D. C., is the chairman of the American committee. Intending members of the Congress may send their names and dues directly to the secretary of the Congress, together with titles of papers to be presented at the meeting, or if preferred, to the chairman of the American committee, who will undertake to forward names, dues and papers to Rome. In case the dues are sent first to Washington for transmission to Rome, a check for $4.00 should be sent to cover dues, exchange and postage.

Western Electrical Directory.—We have received the 1905 edition of this useful directory, published by the Blanchfield Publishing Co., Rialto Building, San Francisco, Cal. The directory contains a list of the central stations in the following Western States: Alaska, Arizona, California, Colorado, Idaho, Montana, Neveda, New Mexico, Oregon, Utah, Washington, Wyoming, El Paso, Texas, Territory of Hawaii, British Columbia, Yukon Territory, Alberta, Saskatchewan, Assiniboia and a portion of Mexico. States and cities or towns are arranged alphabetically. Following the name of the city the population is given, then the name of the operating company and the names of its officers, capital stock and equipment of plant. The price of the directory, including quarterly reports until the 1906 issue, is $5.00.

Diary.—We have received from Messrs. Geo. G. Blackwell, Sons & Co., a very handsome pocket diary, bound in red morocco. This is the pioneer firm of ferroalloys in Great Britain, and was founded in 1869.

Storage Batteries.—A small folder, recently issued by the Westinghouse Machine Company, deals with the use of storage batteries for electric signal systems. It is chiefly interesting as the first publication of the Westinghouse Machine Company on their storage batteries.

Siloxicon Articles.—According to the Niagara Falls "Gazette" of Oct. 2, "a big new industry for Niagara Falls is forecasted in the form of the Acheson Siloxicon Articles Co. It was recently incorporated in the State of Maine, with a capital of $500,000. The location of the factory will be at Niagara Falls. The company will utilize crude siloxicon and make from it such articles as crucibles, muffles, brick, etc. Siloxicon, as is well known, is a highly refractory material, and it is believed from the present demand for it that it will supersede many of the older forms of refractory materials." Siloxicon is really a series of silicon-carbon-oxygen compounds, for the production of which Mr. Acheson designed an electric furnace with very exact temperature regulation (see our Vol. I., p. 287). An article on the oxidation of siloxicon from the pen of Mr. E. G. Acheson himself may be found on page 373 of our Vol. I., while the use of silico-carbides as refractory material was discussed in an article by Mr. F. A. J. FitzGerald, our Vol. II., p. 442.

Liquid Barretter Patent.—The Fessenden patent for a "liquid barretter" as receiver in wireless telegraphy has recently been adjudicated and sustained, the decision being rendered by Judge Hoyt H. Wheeler. The patent is interesting not only account of the high efficiency of the device, but because it is probably the only application of electrochemistry in wireless telegraphy. The liquid barretter consists essentially of a cell comprising a suitable liquid and suitable electrodes, one of them, usually the anode, having only a minute surface exposed to the liquid; the wireless signals are caused by an increase of the current in the battery circuit in response to the action of received oscillations which pass through the electrodes and cell in parallel with the battery circuit.

Electric Steel Furnace.—According to a report from San Francisco, 1 ton of black beach sand from Guadalupe, Cal., has been treated in Portland, Ore., and over 600 pounds of steel produced therefrom by the use of an electric smelting furnace after concentrating. A small quantity of sand from A. B. Hammond's property, on the Oregon coast near the mouth of the Columbia River, was also put through the process of separating the magnetite from the other minerals. The work was done at the pavilion of the Geological Survey on the grounds of the Lewis and Clark Exposition, under the direction of Mr. David T. Day, chief of the Division of Mining and Mineral Resources. Mr. C. E. Wilson, of Virginia, had charge of arranging the electrical details. A larger electric furnace will be constructed, and Dr. Day will continue his tests until the value of the black sand of the coast has been determined. The most practicable method of making pig iron and steel commercially will be ascertained. The sand can be obtained at several hundred places along the Pacific Coast. Some gold is recovered by the new process.

The Electric Furnace in Metallurgy.—Under this title, Mr. M. Robert Pitaval presented a suggestive paper before the recent International Mining Congress in Liege. "At the World's Fair in Paris in 1900, two or three electric fur-

naces of small dimensions could be seen. * * * These were curiosities of the laboratory. Now, at Liege, we see in the electrical and metallurgical sections mighty ingots of steel, blocks of ferrosilicon, ferrochrome and other alloys, produced on a large scale in the electric furnace and sold in quantities of many tons to metallurgical works." The paper gives a full review of what has been done in electric steel refining. "The temperature of at least 2000° C. which is obtained in the electric furnace—i. e., 800° C. above that of the open-hearth furnace— permits a very complete deoxidation of the steel, almost perfect removal of sulphur and phosphorus; this high temperature removes any danger that the metal might over-oxidize and become pasty, as is the case if the refining process is prolongated too long in the ordinary metallurgical furnace. Since this high temperature is produced within the mass of the metal itself and not on the surface, as in the open-hearth furnace, there is no possibility of portions of slag intermixed with the metal. Finally, the neutral atmosphere on the surface of the bath in the electric furnace permits the use of very basic slags and fluxes which could not be used in the open-hearth furnace. At the end of the refining process it is thus possible to use a slag by which the latest traces of phosphorus are eliminated." The electric furnace permits an easy and cheap refining of common steel. "L'acier a tué le fer, mais le four élictrique tuera l'acier ordinaire."

Centrifugal Filter.—For the purpose of using lubricating oil over and over again, the oil must be filtered and cleaned after use. A centrifugal filter has been used for this purpose in various forms in this country. In a consular report of Oct. 7 an apparatus of Heine Brothers, in Viersen, Rhineland, Germany, is described. "This oil filter consists of a perforated cylinder-shaped drum, in which the concrete mass is placed. Only 5 minutes' time is necessary by centrifugal force to drive every particle of mucous oil out of the mass placed in the cylinder. This oil is drained into a separate vase, from which it can be removed ready for use. There is a crane attachment, which enables the perforated cylinder to be easily emptied and cleaned."

Lead-Lined Iron Pipes.—We have received the catalogue of the Lead-Lined Iron Pipe Co., of Wakefield, Mass. manufacturers of lead-lined and tin-lined iron pipes. The company was founded some fourteen years ago, and its business has steadily grown, not only in connection with the better recognition of the importance of lined pipes for water-works, but as a result of the marvelous growth of chemical and metallurgical industries in this country. In the latter case lead-lined pipes are an economical necessity wherever acids are to be handled. Acids corrode all kinds of iron pipe, brass pipe and copper, but do not affect lead pipe, provided it is pure lead. The joints on lead-lined iron pipe for acids or chemicals are flanged, thereby ensuring a perfectly tight joint. For hot acids a hardened lead is used. The Anaconda, Amalgamated and United Verde copper mining companies are using this lead-lined pipe where there are acid corrosive properties in the water. The Lead-Lined Iron Pipe Co. received a gold medal at the St. Louis World's Fair.

Assayers' and Chemists' Supplies.—We have received the 1905 catalogue of assayers' and chemists' supplies of the Denver Fire Clay Co., in Denver, Col. The great variety of the laboratory supplies covered in this illustrated catalogue is well-known to assayers and chemists, who often use it as a reference book. Among the novelties in the new edition may be mentioned crucible and muffle gasoline furnaces, now manufactured by this company.

Hancock Jig.—Bulletin 1403 of the Allis-Chalmers Co. deals with the Hancock jig, which is of Australian origin, and was invented by Mr. H. R. Hancock, then general manager of the Moonta mines in South Australia. It has proven very successful in treating the low-grade sulphide ores of the Broken Hill district. The present pamphlet gives a fully illustrated description of the jig and the results obtained with the first jig installed in the mill of the Arizona Copper Co., and confirmed by working tests made at other plants. The characteristic features of the Hancock jig are stated to be a very large production; a marked ability to handle an unsized feed (the jig is now opearting in this country on coarse material which averages from ½ inch down to 3 m/m and from m/m to 40-mesh material); small amount of water required in the jigging operation (at least 50 per cent less than in the plunger jig); the jig will handle 100 tons per day as well as 500 to 600 tons.

Cranes.—Section E of the serial bulletins of the Wellman-Seaver-Morgan Co., of Cleveland, on iron and steel works equipments deals with cranes, and gives profusely illustrated descriptions of various types of cranes built by that company. The first part of the bulletin describes details of the Wellman patented double-trolley ladle cranes, which are particularly adapted for steel plant practice, both for handling hot metal to and from the mixers and charging it into the furnaces, and for handling molten steel from the furnaces. The second part of the bulletin deals with standard electric overhead traveling cranes for general purposes, followed by notes on standard locomotive cranes and gantry and yard cranes. The Wellman-Seaver-Morgan Co. also build special purpose cranes for all classes of crane service, including charging and manipulating cranes for steel plant work, ingot extracting cranes, soaking pit cranes, etc.

Saw Mill Carriages.—Catalogue No. 123 of the Allis-Chalmers Co. deals with saw mill carriages and accessory machinery (Pacific Coast power set works, Pacific Coast carriages, reliance carriages, blocks, knees, spring cushion taper movement, dogs, set works, automatic spring cushion offset, carriage tracks, couplings, buffers). In the manufacture of head blocks and set works, and in fact all their machinery, the Allis-Chalmers Co. use special tools which, together with their system of making every part and piece to gauges or template, insures perfect fitting and perfect work. Mill men, especially mill foremen, will appreciate this system of doing work, as it is a guarantee that when a piece is ordered to replace a worn or broken part it will go to its place without filing or fitting. The catalogue mentioned above describes in detail the various parts that make up the reliance carriages of the Allis-Chalmers Co., and is profusely illustrated.

Rotary Converters.—Special publication 7038 of the Westinghouse Electric & Mfg. Co. deals with rotary converters, their characteristics and construction, with instructions for their erection, operation and care. As the connecting link between alternating and direct-current systems, the rotary converter has naturally found the largest application in sub-stations for direct-current street railway supply in connection with high-tension alternating-current transmission. But its field of usefulness is much wider. Alternating current is now considered "the" system for transmission and distribution over large areas. Wherever at a customer's premises direct current is preferable (as for certain power purposes) or absolutely necessary (as for electrolytic work), the rotary converter steps in. Electrochemical and metallurgical engineers who want to become acquainted with its peculiarities will find a great amount of clean-cut, useful, practical information in this publication of the Westinghouse Co.

Steel and Iron Hardening Metals.—The United States Geological Survey has recently issued the report by Mr.

Joseph Hyde Pratt on the production of steel and iron hardening metals in 1904 (including nickel and cobalt, chromium, tungsten, molybdenum, vanadium, titanium and uranium). The introduction deals with the production of pure metals free from carbon, and discusses the aluminothermic method of Goldschmidt, the electric furnace method of Rossi, with aluminium as reducing agent, and the method of Greene and Wahl. The different metals mentioned above are then discussed in detail with respect to occurrences, localities and production in 1904. The report contains much useful information, especially on ferrochrome and ferrotungsten.

Commercial Examination of Fuel.—A small pamphlet with this title, issued by Messrs. Waller & Renaud, 159 Front Street, New York City, gives a popular and very clear account of the importance of testing fuel before use in commercial plants and of the methods used in such tests. Not only is the heating power of the fuel in B. T. U. per pound to be determined, but since the latter is always determined on a dried sample, it is necessary to know the percentage of moisture in the fuel to make the required correction. The approximate analysis should give the percentages of moisture, volatile combustible matter, fixed carbon and ash. To this is usually added a determination of the sulphur, since when much sulphur is present, the coal will clinker badly. Messrs. Waller & Renaud have equipped their laboratory with a Berthelot-Mahler-Atwater standard bomb calorimeter, and are prepared to make accurate calorimeter tests of coal and other fuels, as well as the usual approximate analyses, sulphur determinations, analyses of ash, etc.

Producer Gas.—A neatly illustrated pamphlet of the Morgan Construction Co., of Worcester, Mass., gives a full description of the Morgan continuous gas producer. This company has developed this new producer in connection with the introduction of continuous heating furnaces to supply hot billets to their continuous rolling mills, since it soon became evident that the success of these special furnaces depended largely upon securing a gas of uniform quality and in uniform quantity. The advantages of the Morgan continuous gas producer are said to be as follows: Complete gasification (the cold ashes containing usually less than 0.5 per cent of the carbon in the original coal); the production of a gas containing the lowest possible percentage of nitrogen and carbonic acid (usually not more than 48 per cent N and 4 per cent CO_2); the delivery of the gas uniform both as to quality and quantity; the automatic disintegration of the clinkers; continuous operation without periodical stoppages for cleaning out; reduction of manual labor to a minimum.

Steam Turbines.—The growing commercial importance of steam turbines is indicated by the following note on one week's business of the Westinghouse Co. in steam turbines. During the week ending Sept. 29, 1905, the Westinghouse companies received orders from the Toledo Gas, Electric & Heating Co., Toledo, Ohio, for two 1000-kw. turbogenerator sets, the Pennsylvania Railroad Co. for four 500-kw. turbogenerator sets, the Water, Light & Gas Co., of Hutchinson, Kan., for two 500-kw. turbogenerator sets, and the Solvay Process Co., of Syracuse, N. Y., for one 500-kw. turbogenerator set. Each turbine will be of the type known as the multiple-expansion parallel flow, with an overhead capacity when running condensing of at least 50 per cent, and the alternating-current generators will be of the turbo-type with rotating fields. The 500-kw steam turbine for the Solvay Process Co. will operate with dry, saturated steam at the throttle of 125-pounds gauge pressure and 28-inch vacuum. The 60-cycle direct-connected turbogenerator will deliver two-phase current at 440 volts. This company already has in operation a number of Westinghouse steam and gas engines, in addition to 3500 hp. in Roney mechanical stokers. Westinghouse apparatus is also installed in the Detroit plant of this company.

Insulating Shellac.—The "Agate Shellac" for insulating purposes, which was noticed in these columns some time ago, has received the highest award in its class at the International Exhibition in Liege, namely, one gold medal in the third class and one silver medal in the second class. Mr. Felix Hamburger, of 90 William Street, New York City, is the representative of the manufacturers of agate shellac in this country.

Personal.

Mr. HERMAN A. METZ, the well-known importer of chemicals and dyestuffs, has been nominated for the position of Controller of New York City on the regular Democratic ticket. The Chemists' Club, of which Mr. Metz is a trustee, tendered him a reception on the evening of Oct. 28. Mr. Metz has a host of friends among the chemists of this country, who, independent of party affiliations, heartily wish him the fullest measure of success.

Mr. HERBERT HAAS has opened an office as consulting metallurgical engineer at 218 California Street, San Francisco, Cal. Mr. Haas gained his technical experience as chief chemist and superintendent of leading silver-lead and copper custom smelters in the United States and Mexico, also as superintendent of construction of smelting plants. A paper by Mr. Haas was published on page 101 of our present volume. Mr. Haas will make a specialty of the metallurgy of copper and lead, the design and erections of copper and lead reduction works along modern and approved lines, and will give special attention to pyritic smelting.

Dr. KARL GOLDSCHMIDT is at present in this country in the interest of the rapidly expanding business of the Goldschmidt Thermit Co., which is the American branch of the chemical and tin smelting works of Theodor Goldschmidt, Essen-Ruhr, Germany. The two brothers, Dr. Karl and Dr. Hans Goldschmidt, are the owners of this firm, founded in 1847, and widely known through its effective pioneer work in electrolytic detinning, and in recent years through Dr. Hans Goldschmidt's celebrated aluminothermic process. Dr. Karl Goldschmidt intends to sail for Germany on Nov. 7, on the "Kaiser Wilhelm II."

Mr. GEORGE G. BLACKWELL, head of the firm of George G. Blackwell, Sons & Co., Ltd., of Liverpool, manufacturers and dealers in ferro-alloys, rare ores and supplies for chemical and metallurgical manufacturing plants is making his annual visit to this country. He makes an extended trip throughout the East and Middle West and to the principal cities in Canada, and will sail early in December for Liverpool. This concern is one of the oldest in the ferro-alloy business, having been established by Mr. Blackwell himself in 1869.

Dr. P. HEROULT, Mr. R. TURNBULL and Mr. J. SEJOURNET left New York on Oct. 18 to start the plant at Sault Ste. Marie, in which, with the coöperation of the Canadian Government and of the Lake Superior Power Co., the use of the electric furnace for the reduction of pig iron from ore will be studied. The electric furnace, which has already been completed, has a capacity of 2 to 4 tons a day. The intention is to carry out the operation in such a way as to oxidize all the fuel, used for reduction, to CO_2 within the furnace, so as to utilize its calorific value to the utmost, water-power being so abundant that its consumption compared with that of fuel is considered secondary. It is suggested to use charcoal and charred peat as fuel.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC SMELTING AND REDUCTION PROCESSES.

(Concluded.)

No. 677,207, June 25, 1901, Charles M. Hall, Niagara Falls, N. Y.

Purifies bauxite and other oxides of aluminium containing as impurities oxides of silicon, iron, titanium, etc., by fusing them with an electric current, with little or no flux, and then reducing the impurities in the fused bath. Example: Bauxite, containing alumina, 60; ferric oxide, 18; silica, 2-3; titanic acid, 3-4, and water, 17, is calcined to remove the water. Before calcination, 5 to 10 per cent of powdered charcoal or coke may be added, to remove the water more completely and partially reduce the iron oxide. The calcined product is then mixed with powdered carbon to give a mixture containing 8 to 10 per cent of carbon and fused in an electric furnace. Less carbon may be added if it be supplied by the carbon of the electrodes and furnace lining. With a furnace of 8 inches internal diameter, a direct or alternating current of 1500 amps. at 28 volts is suitable, effecting the fusion and reduction in 1 hour. The reduced iron, silicon and titanium unite to form a fused alloy, the bulk of which settles to the bottom. The mass is then allowed to cool and the alloy separated, the particles which are distributed through the alumina being picked out by a magnet. Or the molten alumina and alloy may be tapped out. The purified alumina is pulverized and is then suitable for solution in fused baths for the production of aluminium. During the operation the molten alumina is covered with a layer of unfused bauxite, which in turn melts. At the end the bath may be covered with a layer of carbon or purified alumina. The furnace shown is a carbon-lined pot, serving as one electrode, into which depends a carbon-rod electrode. This rod may be raised slightly above the molten material, apparently forming an arc. Two depending electrodes of opposite polarity may be used. For a furnace having a chamber 16 inches in diameter and 24 inches deep, an alternating current of 1500 to 2000 amps. at 60 volts is suitable. Incandescent electric furnaces may also be used, the heat being generated either in the material or in a separate carbon resistance.

No. 677,208, June 25, 1901, Charles M. Hall, Niagara Falls, N. Y.

Purifies bauxite and other oxides of aluminium containing as impurities oxides of silicon, iron, titanium, manganese, vanadium, etc., by mixing with powdered aluminium or ferro-aluminium and melting the mixture. The reduced impurities combine into an alloy. Example: Calcined bauxite, containing alumina, 72.9; silica, 1.3; ferric oxide, 22.7, and titanic acid, 3.1, is mixed with sufficient powdered aluminium or ferro-aluminium to reduce the oxide impurities, the amount of aluminium preferably used being equal to 37.5 per cent of the ferric oxide, 65 per cent of the silica, and 50 per cent of the titanic acid. The mixture is fused in a carbon-lined electric furnace, and is maintained in fusion for one and one-half hours, when the charge contains 300 pounds of bauxite. The reduced metals combine as a molten alloy which generally sinks to the bottom, but may collect in globules or buttons. The heat evolved in the reaction assists in the fusion. The furnace may be a carbon-lined pot constituting one electrode, into which depends a carbon-rod electrode, which is gradually raised to keep it above the surface of the fused mass. As the charge mixture fuses more may be added until the furnace is nearly full, purified alumina being added to cover the mass at the end of the operation. A potential difference of 60 volts, with sufficient amperage to give 150 to 200 hp. has been employed. After the operation the mass in the furnace may be allowed to solidify and the alloy at the bottom detached, or the molten alumina and alloy may be tapped out. The mixture may be fused by making it a resistance conductor, electrolysis then aiding in the reduction. When the bauxite is low in iron, iron may be added, preferably as an alloy with aluminium. For example, calcined white bauxite, containing alumina, 88.53; silica, 4.3; ferric oxide, 1.57, and titanic acid, 3.6, is mixed with powdered 50 per cent aluminium in such amount that the contained aluminium equals 5.8 of the bauxite. Where the bauxite contains much iron, carbon may be added to the charge to assist in the reduction.

No. 681,367, Aug. 27, 1901, Hugh A. Irvine, Niagara Falls, N. Y.

Electrically generated heat for the reduction of ores or compounds by employing a resistor of molten slag. In the furnace shown, the hearth and sides are lined with carbon. Carbon-rod electrodes of opposite polarity depend through the arched roof. In using this furnace for the production of phosphorus, an initial resistor of coarsely-granulated coke is placed on the hearth of the furnace in contact with the lower ends of the electrodes. The charge, *e. g.*, a mixture of phosphates of calcium and aluminium, mix with crushed coke or anthracite coal, and a silicious, basic or silicate flux, is then gradually added and melted. As fusion proceeds, a body of molten slag accumulates on the hearth, and it carries the heating current as soon as it rises in contact with the lower ends of the electrodes. The excess of slag can be removed through tap-holes. The current may be direct or alternating. The carbon lining of the furnace may constitute one electrode.

No. 685,043, Oct. 22, 1901, William T. Gibbs, Buckingham, Canada.

Effects fusion and reduction by the heat radiated from a carbon-rod resistor, extending horizontally through the furnace above the charge. The furnace chamber may consist of firebrick or carbon, preferably having an arched roof to reflect the heat downward. One resistance rod, or several connected in series, may be used, extending between massive carbon blocks, which are set in iron sockets embedded in the side walls. The furnace has a charging opening through one side wall and a tap-hole and gas outlet through the other.

No. 693,482, Feb. 18, 1902, Edward G. Acheson, Buffalo, N. Y.

Reduces ores, for example, silica, by coating the particles of ore with graphite and employing a mass of the coated particles as a resistor. Acheson graphite is preferably employed, and is applied by mixing the ore and graphite and subjecting the mixture to a tumbling or rubbing process, by which the graphite is spread upon the surface of the particles. Example: Silica, 150 parts, is mixed with Acheson graphite 55 parts, and the mixture is rubbed in a mortar or tumbled in a barrel. The charge is then placed in an electric furnace between suitable terminals, fine silica being placed beneath, at the sides and on top of the charge. In one experiment the terminal electrodes had an exposed end surface of 4 square inches, and were separated 3 inches, the intervening space measuring 3 x 2 x 2 inches. The current, beginning with 3 amps. at 100 volts, rose in 7 minutes to 18 amps., and was turned off after 25 minutes. Globules of pure silicon were found scattered through the unreduced portions of the charge. Suggests that the furnace product may be removed intermittently, in a fluid or solid condition, or continuously in a solid, liquid or gaseous state. When the product is a volatile metal, such as zinc, condensers are provided. Alloys may be made by employing a mixture of graphite-coated particles of ores of two or more metals. Carbides may be made by employing an excess of graphite.

No. 701,718, June 3, 1902, C. M. Hall, Niagara Falls, N. Y.

The alloy of iron and silicon, titanium, aluminium, manganese, etc., produced by reducing the oxide impurities of bauxite and other impure oxides of aluminium, as described in the Hall patent 677,207, is used as a pigment, being pulverized in a mill and then mixed or ground with oil.